RUSSIAN RIVER
BIOLOGICAL ASSESSMENT

Prepared for:

U.S. ARMY CORPS OF ENGINEERS
San Francisco District
San Francisco, California

and

SONOMA COUNTY WATER AGENCY
Santa Rosa, California

Prepared by:

ENTRIX, INC.
Walnut Creek, California

September 29, 2004

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Term	*Definition*
A	
ADCP	Acoustic Doppler Current Profiles
ADFG	Alaska Department of Fish and Game
ADWF	average dry weather flow
AF	acre-feet
AFY	acre-feet per year
ARM Plan	Aggregate Resource Management Plan
ASR	aquifer storage and recovery
Avg FPP	average size (fish per pound) at release
AWG	Agency Working Group
B	
BA	Biological Assessment
BASMAA	Bay Area Stormwater Management Agencies Association
BKD	Baterial Kidney Disease
BML	Bodega Marine Laboratory
BMPs	best management practice(s)
BO	Biological Opinion
BOD	biological oxygen demand
BRA	Benefit Risk Analysis
C	
CCC	Central California Coast
CCF	hundred cubic feet
CCR	California Code of Regulations
CDF	California Department of Forestry and Fire Protection
CDFG	California Department of Fish and Game
CDHS	California Department of Health Services
CDOC	California Department of Conservation

Term	*Definition*
CDOF	California Department of Finance
CDWR	California Department of Water Resources
CEQA	California Environmental Quality Act
CESA	California Endangered Species Act
CFR	Code of Federal Regulations
cfs	cubic feet per second
cfs/hr	cubic feet per second per hour
cm	centimeter(s)
CMRPD	Camp Meeker Recreation and Parks District
cm/s	centimeters per second
CPP	Continuing Planning Process
CPUE	catch per unit effort
CRWQCB	California Regional Water Quality Control Board
CSR	coho salmon replacement rates
CTR	California Toxics Rule
CVDP	Coyote Valley Dam Project
CVFF	Coyote Valley Fish Facility
CWA	Clean Water Act
D	
D1610	SWRCB Decision 1610
DCFH	Don Clausen Fish Hatchery (also known as Warm Springs Fish Hatchery)
DEIS	Draft Environmental Impact Statement
DO	dissolved oxygen
E	
EIR	Environmental Impact Report
EIS	Environmental Impact Statement
El.	elevation
EPA	U.S. Environmental Protection Agency

Term	*Definition*
ESA	Federal Endangered Species Act of 1973
Estuary	Russian River Estuary
ESU	Evolutionarily Significant Unit
EWSL	Emergency Water Supply Line
F	
FEIS	Final Environmental Impact Statement
FEP	Fisheries Enhancement Program
FERC	Federal Energy Regulatory Commission
FL	fork length
FMEP	Fisheries Management and Evaluation Plan
FMMP	Farmland Mapping & Monitoring Program
FPP	fish per pound
fps	feet per second
FR	Federal Register
ft/hr	feet per hour
ft^3	cubic feet
G	
GIS	Geographical Information System
gpd	gallons per day
gpm	gallons per minute
H	
HGMP	Hatchery and Genetic Management Plan
hp	horsepower
hr	hour(s)
HSA	Hydrologic Service Area
I	
IPM	Integrated Pest Management
IPOTW	Ignacio Publicly Owned Treatment Works

Term	*Definition*
J	
K	
km	kilometer(s)
km/h	kilometer(s) per hour
KRIS	Klamath Resource Information System
KW	kilowatt(s)
L	
lb	pound
lf	linear feet
LMHPP	Lake Mendocino Hydroelectric Power Plant
M	
m^3/s	cubic meter(s) per second
M&E Plan	Monitoring and Evaluation Plan
MCIWPC	Mendocino County Inland Water and Power Commission
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
MG	million gallons
mgd	million gallons per day
mg/l	milligram(s) per liter
mi^2	square miles
min	minute(s)
ml	milliliter
mm	millimeter(s)
MMWD	Marin Municipal Water District
MOU	Memorandum of Understanding
MSC	Merritt Smith Consulting
MSL	mean sea level
MTBE	methyl tertiary-butyl ether
Mt DNA	Mitochondrial DNA

Term	*Definition*
MW	megawatt(s)
N	
NaOH	sodium hydroxide
NATURES	Natural Rearing Enhancement System
NBWA	North Bay Watershed Association
NCPA	Northern California Power Authority
NCRWQCB	North Coast Regional Water Quality Control Board
NCWAP	North Coast Watershed Assessment Program
NEPA	National Environmental Policy Act
NFP	Natural Flow Proposal
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service, now known as NOAA Fisheries
NMWD	North Marin Water District
NOAA	National Oceanic and Atmospheric Administration
NOAA	National Marine Fisheries Service
NPDES	National Pollutant Discharge Elimination System
NPOTW	Novato Publicly Owned Treatment Works
NPS	nonpoint source (discharge)
NTU	Nephelometric turbidity unit
O	
OCSD	Occidental County Sanitation District
ODFW	Oregon Department of Fish and Wildlife
O&M manual	operation and maintenance manual
P	
PG&E	Pacific Gas and Electric Company
PIT	Passive Integrated Transponder
PL	Public Law
PMG	Prince Memorial Greenway
PPFC	Public Policy Facilitating Committee

Term	***Definition***
ppm	parts per million
ppt	parts per thousand
PVID	Potter Valley Irrigation District
PVP	Potter Valley Project
Q	
QPF	Quantitative Precipitation Forecast
R	
RFP	Request for proposal
Rkm	river kilometer
RM	river mile
RMA	Resource Management Associates
RRCWD	Russian River County Water District
RREITF	Russian River Estuary Interagency Task Force
RRSM	Russian River System Model
RRWQM	Russian River Water Quality Model
S	
SAR	smolt-to-adult return
SCWA	Sonoma County Water Agency
SD	Sanitary District
SFBRWQCB	San Francisco Bay Regional Water Quality Control Board
SL	standard length
SPCC	Spill Prevention, Containment, and Control plans
sq mi	square mile
SRSWRS	Santa Rosa Subregional Wastewater Reclamation System
SVCSD	Sonoma Calley County Sanitation District
SVOC	Semi-volatile organic compounds
SWMP	Storm Water Management Program
SWRCB	State Water Resources Control Board

Term	*Definition*
T	
TDS	Total dissolved solids
THPs	Timber Harvest Plans
TKN	Total Kjeldahl Nitrogen
TMDL	Total Maximum Daily Load
TRT	Technical Recovery Team
TSS	total suspended solids
U	
USACE	U.S. Army Corps of Engineers
USBR	U.S. Bureau of Reclamation
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
USSCS	U.S. Department of Agriculture Soil Conservation Service (now known as Natural Resources Conservation Service)
V	
VESCO	Vineyard Erosion and Sedimentation Control Ordinance
VOC	volatile organic compounds
VOMWD	Valley of the Moon Water District
W	
WDFW	Washington Department of Fish and Wildlife
WDR	Waste Discharge Requirements
WEP	Water Education Program
WLA	Waste Load Allocation
WQM	Water Quality Monitoring
WSDP	Warm Springs Dam Project
WSE	water surface elevation
WSTSP	Water Supply and Transmission System Project
WWTP	Wastewater Treatment Plant

Term	*Definition*
X	
Y	
YOY	young of the year
Z	

The U.S. Army Corps of Engineers (USACE), the Sonoma County Water Agency (SCWA), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the federal Endangered Species Act (ESA) with the National Oceanic and Atmospheric Administration (NOAA Fisheries) to evaluate the potential effects of their proposed operation and maintenance activities in the Russian River on listed salmonid species and their habitat.

This document, the Biological Assessment (BA), provides a description of environmental baseline including historical project operations and maintenance procedures. It presents proposed structural changes to project facilities and proposed changes to project operations and maintenance procedures. The BA evaluates the effects of the proposed project including ongoing project operations and proposed changes to project facilities, operations and maintenance procedures on threatened stocks of coho salmon, steelhead, and Chinook salmon. Section 1 presents the scope of the BA and describes the institutional agreements and constraints related to the project facilities and operations. Section 2 describes environmental baseline conditions in the watershed from a regional perspective and summarizes the status of the listed salmonid species in the Russian River. Section 3 describes baseline operations of project facilities and identifies the effects of these operations on salmonids. Section 4 presents a detailed description of the proposed project under consideration and the conservation actions that would be taken to improve habitat conditions for listed salmonids. The proposed project has seven different activities: 1) flood control operations, 2) hydroelectric operations, 3) water supply and transmission operations, 4) flow and estuary management, 5) channel maintenance for flood control and water supply needs, 6) restoration and conservation activities, and 7) operation of the fish production facilities.

The next three sections of the BA examine the direct and indirect impacts of the project on coho salmon, steelhead, and Chinook salmon. Section 5 gives an analysis of the effects of the proposed activities on the different lifestages of each listed fish species, and compares these effects to baseline conditions. Section 6 considers all project activities in concert to characterize their collective effect on each fish species. This section examines all project activities in an integrated manner to determine whether the proposed project would improve habitat conditions for listed salmonids over baseline, and decrease the chance of population extinction. Finally, the effects of interrelated/interdependent activities and effects of future nonfederal actions (cumulative effects) are evaluated in Section 7. Five activities were identified as *interrelated or interdependent* to the proposed project: 1) water transmission to the service areas of SCWA's contractors and customers, 2) non-native fish stocking in project reservoirs, 3) recreational fishing activities for hatchery produced steelhead, 4) channel maintenance of Public Law (PL) 84-99 (nonfederal) sites in the Russian River and Dry Creek, and 5) operations of the City of Ukiah's Hydroelectric Project. Section 8 presents the references cited in the document and the information obtained from personal communications with other individuals and internet web sites. Section 9 provides definitions of technical terms used in the document. Section 10 provides photos of the facilities and project features.

The Appendices include supplemental information to provide the reader with additional information on the results of the analysis, as well as other reports used in the preparation of the BA. Appendix A presents an evaluation of alternative actions that were considered, but not proposed, as part of the project description. Appendix B includes information on the methods used to determine the effects of project flows on the listed species and describes the permit terms that would be requested for the water rights held by SCWA. Appendix C presents the information on the evaluation criteria used in the effects analysis (Section 5). Appendix D, Preliminary Recreational Analysis for the Flow Proposal, and Appendix E, Economic Analysis for the Russian River BA, include supplemental studies conducted to assist in the development and evaluation of the alternative scenarios for managing instream flows in the Russian River and Dry Creek.

The BA will be submitted to NOAA Fisheries. NOAA Fisheries will then prepare a Biological Opinion (BO) for the proposed project. A proposed monitoring program and an implementation plan for the new facilities will be developed jointly with NOAA Fisheries Implementation of some activities for the proposed project would require environmental review under the California Environmental Quality Act (CEQA) and National Environmental Policy Act (NEPA) as well as other agreements, permits or certifications from other state and federal agencies.

Changes In Current Operations

The proposed project modifies current operations and maintenance practices in the Russian River. Some of the modifications are in progress or are being implemented on a trial basis, while others will require more analysis before they can be fully implemented. A few project operations will require the construction of new facilities. Some will require regulatory approvals or congressional authorizations before they can be implemented.

A major objective for the proposed changes to project facilities and operations is to improve aquatic habitat conditions or reduce the opportunity for injury or harm to listed salmonids. The major proposed changes to current project operations include:

- Make structural and operational modifications at Coyote Valley Dam.
  - Reduce effects to fish during annual inspection and maintenance operations by providing a minimum instream flow and reducing the ramping rate (the rate at which releases from the dam are decreased).
- Make structural and operational changes at Warm Springs Dam.
  - Repair and clean the uppermost tunnel at the control structure of the dam (recently completed) to provide better temperature control for releases.
  - Reduce ramping rates to avoid rapid changes that could strand young fish.
  - Improve the reliability and quantity of the water supply to the hatchery.

- Make structural and operational changes at the Mirabel and Wohler diversion facilities to reduce effects to young fish.
  - Improve fish screens at both diversions.
  - Improve fish passage at the inflatable dam.
  - Reduce the opportunity for entrapment in the infiltration ponds.
- Modify flow releases from Warm Springs Dam and Coyote Valley Dam (after the State Water Resources Control Board (SWRCB) modifies SCWA's water-right permits).
  - Lower instream flows during the summer in Russian River and in Dry Creek below those required under SWRCB Decision 1610 (D1610) to improve summer habitat for listed fish species.
  - Eliminate artificial breaching of the sandbar at the river mouth during the summer to improve summer rearing habitat.
  - Develop additional water supply measures to meet future demand while protecting fish habitat.
- Modify channel maintenance activities.
  - Focus bank stabilization in the Russian River to specific sites and modify protocols to benefit listed fish species.
  - Adaptively manage vegetation and/or sediment maintenance activities in flood control channels and natural waterways to improve habitat, where feasible.
- Revise fish production facility operations to implement:
  - An isolated harvest program for steelhead;
  - An integrated recovery program for coho salmon (beginning with the captive broodstock program);
  - No hatchery production for Chinook salmon; and
  - Future programs that could include an integrated harvest program for steelhead and an integrated recovery program for Chinook salmon, if warranted.

Additional descriptions of proposed changes to facilities and operations are provided below.

FLOOD CONTROL, WATER STORAGE, AND SUPPLY OPERATIONS

Coyote Valley Dam

Under the proposed project, Lake Mendocino would continue to be managed for flood control, water supply, and hydroelectric power generation.

Annual and periodic (5-year) pre-flood inspections and maintenance activities would continue to be performed at Coyote Valley Dam. Reductions in releases from the dam are required to conduct inspections or repairs. Under the proposed project, ramping rates at flows less than 250 cfs would be reduced from 50 cfs per hour (cfs/h) to 25 cfs/h to reduce the risk of stranding fish in the Upper Russian River mainstem. The outlet structure at the dam would also be modified to allow greater control of flows during the ramping-down process.

To avoid dewatering the East Fork Russian River, USACE would install pumps to supply a bypass flow of 25 cubic feet per second (cfs) during inspection and maintenance activities. Dam inspections would also be scheduled later in the season (between July 15 and October 15) so that salmonid fry, which are more susceptible to stranding than larger juveniles, have time to grow. Finally, a 15-cfs release from the bypass pipeline would be used to ensure adequate flows to the Coyote Valley Fish Facility (CVFF), which is located at the base of the dam.

Warm Springs Dam

Lake Sonoma would continue to be operated for flood control, water supply, and hydroelectric power generation. As with Coyote Valley Dam, maintenance and inspection activities are conducted at Warm Springs Dam to ensure proper operations. To avoid dewatering rearing habitat in Upper Dry Creek, flows from the dam would be ramped down at a rate of 25 cfs/h or less during inspections and a minimum bypass flow of 25 cfs would be provided to Dry Creek.

Modifications would be made to the water supply line to the Don Clausen Fish Hatchery (DCFH) to provide a more reliable hatchery water supply. This would improve conditions at the hatchery and help in the implementation of a proposed broodstock program for coho salmon (see below).

Transmission System

SCWA would continue to divert and deliver water to water contractors through their water transmission system. This system consists of diversion facilities, treatment facilities, pipelines, water storage tanks, booster pump stations, and groundwater wells. SCWA would continue to operate and construct the transmission system facilities, as authorized under the Eleventh Amended Agreement for Water Supply (SCWA 2001a), to meet current and future water supply demands.

The inflatable dam at the Mirabel diversion facility would continue to be operated to increase infiltration to the aquifer beneath the river streambed. SCWA plans to create a single depression in the crest of the inflatable dam during the smolt outmigration period to improve fish passage.

Fish screens at the Mirabel diversion facility would be reconfigured to comply with NOAA Fisheries and California Department of Fish and Game (CDFG) fish screen criteria. This will help reduce the risk of impingement of juvenile fish during rearing and downstream migration. If needed, the fish ladder and the bypass pipeline on the east side of the dam would also be modified to improve fish passage.

At the two Wohler infiltration pond diversions, new intake structures and new fish screens would be installed to protect young fish when the diversions are in operation. The fish screens would be removed when the Mirabel inflatable dam is lowered. Fish entrained during winter storms could return to the river. The infiltration ponds would be graded to promote drainage back to the river and reduce the risk of stranding fish. Fish rescues would continue to be conducted if needed.

Flow Management

Analyses conducted to date indicate that habitat for listed fish species could be improved by decreasing summer flows (ENTRIX, Inc. 2003b). Under the proposed water management (Flow Proposal), releases from Warm Springs and Coyote Valley dams would be modified to improve rearing and migration conditions for salmonids in the Russian River, Dry Creek, and the Estuary. The Flow Proposal would also provide sufficient water to satisfy existing water demand in the Russian River and Dry Creek, and meet future demands on the SCWA system as defined by the Water Supply and Transmission System Project (WSTSP). To implement the Flow Proposal, D1610 would need to be modified by a new order from SWRCB.

The most substantial changes under the Flow Proposal would be a reduction in downstream flow from Coyote Valley Dam and Warm Springs Dam between June and October. For example, under the current D1610 management scenario, summer flows in the Russian River near Ukiah are typically about 230 cfs. The Flow Proposal would provide summer median monthly flows that would typically range from 140 to 185 cfs. Median monthly flows in Dry Creek would decrease by 32 to 34 percent under the Flow Proposal relative to D1610 under *all* water supply conditions and by 40 to 44 percent in *dry* water supply conditions. Overall, the Flow Proposal would increase the quality and quantity of summer rearing habitat for salmonids under current and future water demand levels in Dry Creek and the upper and middle mainstem Russian River.

The lower flows in the Russian River would allow flows downstream of the Mirabel inflatable dam to be managed so the quantity of water flow into the Russian River Estuary (Estuary) would be low enough to maintain the Estuary as a closed system. This action would avoid artificial breaching of the sandbar at the river mouth during summer. It would thus improve summer rearing habitat in the Estuary and would create better conditions for upstream migration of Chinook salmon. Artificial breaching may still be required to prevent flooding to private property and roads during storms, primarily in the fall.

The Flow Proposal would provide median monthly flows of 52 to 78 cfs from July through September in *normal* and *dry* years. In *critically dry* years, flows could drop to the minimum flow of 35 cfs. (See Table 4-5 and Table 5-35 for additional details on expected flow rates.)

The goal of the Flow Proposal is to maintain suitable rearing habitat for listed salmonids. Because the lower flow rates necessary for suitable rearing habitat would make it more difficult for SCWA to meet future supply demands of the water contractors, additional water-supply measures would be needed so that SCWA could continue to meet all of its contractors' demands for water. Some of the measures under consideration include an aquifer storage and recovery (ASR) program, additional diversion facilities, and new raw water pipeline. SCWA is reviewing the types and feasibility of these facilities to meet water supply needs.

Channel Maintenance

Channel maintenance activities would continue to be conducted in the Russian River and its tributaries to reduce the potential for flooding and bank erosion. Current activities include sediment removal and vegetation maintenance, channel debris clearing, and bank stabilization activities.

SCWA is assessing the capacity of flood control channels in the Russian River basin. Where flood capacity allows, sediment and vegetation maintenance practices would be modified to reduce potential adverse effects on fish while maintaining sufficient flood capacity. For example, in channels where it is determined that flood capacity can be maintained, some canopy cover would be allowed to develop on the upper banks. Moreover, young trees (thinned and pruned) would be allowed to colonize the lower banks to improve conditions for rearing and upstream migration.

SCWA and MCRRFCD bank stabilization activities in the mainstem Russian River would also be modified to reduce potential negative effects on listed fish species. Gravel-bar regrading and overflow channel creation would generally be limited to areas with potentially severe bank erosion. Bank stabilization projects would also be conducted when levees are weakened, or where a flooding threat to infrastructure or private property exists. If appropriate, bioengineered structures may be installed to stabilize banks that are found to consistently be at risk of eroding. The USACE would review and revise its channel maintenance requirements in its Operation and Maintenance (O&M) Manuals to provide greater protection for salmonids in the Russian River.

Vegetation maintenance may also occur where there is encroachment of exotic pest plants such as *Arundo donax* (giant reed).

Habitat Restoration

SCWA plans to continue its proactive role in habitat restoration and enhancement projects, and in promoting measures that contribute to the heath of the ecosystem and the watershed. These efforts include support for state and federal recovery plans, watershed management, riparian and aquatic habitat protection, instream restoration projects, improvements to fish passage, and water conservation and recycling. To maximize the effectiveness of dollars invested, SCWA plans to assist in developing project priorities on a basin-wide level, in cooperation with CDFG, other public agencies, and private interests in the watershed. SCWA would also continue its public information and education programs to increase awareness of the importance of protecting and restoring habitat for listed species.

SCWA provides potable water to eight cities in Sonoma County (water contractors) through its water supply and transmission system. SCWA is in the process of implementing a water-recycling program to reduce the amount of water taken from the Russian River during the peak water demand season. The recycling program would redistribute tertiary-treated wastewater from the water contractors for the irrigation of agricultural crops. This would potentially help restore suitable flow conditions for salmon in tributaries to the Russian River and improve the reliability of the water supply for agricultural purposes in Sonoma County.

Fish Production Facility Operations

The DCFH and CVFF were developed to mitigate for lost habitat upstream of Warm Springs Dam and Coyote Valley Dam, respectively. Fish production goals for DCFH were established to compensate for loss of coho salmon and steelhead production in Dry Creek (mitigation goals) and to enhance harvest opportunities for coho salmon and Chinook salmon in the Russian River. Fish production goals for CVFF were established to compensate for the loss of steelhead production in the East Fork Russian River upstream of Coyote Valley Dam.

Since the 1999/2000 season, an interim operations plan led to the cessation of hatchery production of coho salmon and Chinook salmon in the Russian River basin. Steelhead production goals, however, remained unchanged from the original mitigation plans. In 2001, a pilot program was implemented to analyze the effectiveness of a captive broodstock program for coho salmon. The coho salmon program is authorized through June 2007 to allow time for adequate implementation and analysis of the enhancement response (NMFS 2001a).

Under the proposed project, mitigation obligations of USACE for coho salmon, steelhead, and Chinook salmon would be formally revised to provide objectives that are realistic and feasible under current environmental and regulatory conditions.

The proposed project for coho salmon is a supplementation program to support recovery, which would include the current pilot captive broodstock program. This program is designed to conserve genetic resources of the Russian River coho salmon population, which is at risk of extirpation.

The steelhead isolated harvest program would provide opportunities for recreational fishing. The isolated harvest program has the potential to result in genetic effects to the remaining Russian River steelhead population. An integrated recovery program for steelhead (which would incorporate wild steelhead into hatchery broodstock to maintain genetic diversity and reduce domestication) would be evaluated for potential future implementation to reduce the risk of genetic effects to the naturally-spawning population.

Chinook salmon production is not proposed because short-term data suggest the naturally-spawning population appears large enough to sustain itself. If new information indicates it is warranted, a supplementation program could be implemented for Chinook salmon.

Under the proposed project, fish production practices would be modified to minimize genetic and ecological effects to naturally spawning populations. Additional facilities would be constructed to provide a more reliable water supply to the hatchery and to support the coho salmon supplementation program.

POTENTIAL EFFECTS ON COHO SALMON, STEELHEAD, AND CHINOOK SALMON

In the Russian River system, the proposed project is likely to result in both positive and negative effects on listed salmonid species. The proposed project would reduce many of the potential negative effects under current baseline operations to a low or negligible risk level, remove the negative effect altogether, or provide a potential benefit to salmonids in the Russian River.

The potential effects of the proposed project on coho salmon, steelhead, and Chinook salmon are summarized below.

Coho Salmon

Coho salmon rear in Dry Creek and in tributaries to Dry Creek and the Lower Russian River. They have also been observed in tributaries in the Upper Russian River.

Project activities that would provide the greatest benefit to coho salmon in these reaches are the habitat restoration projects in priority coho salmon tributaries, and implementation of the Flow Proposal and the captive broodstock program. Instream habitat restoration would increase the quality of coho salmon habitat by providing more pools for rearing juveniles and improving fish passage to spawning grounds. The Flow Proposal would provide better rearing flows in Dry Creek during the summer and fall, which should improve juvenile survival rates. Finally, the broodstock program would increase the distribution of coho salmon by allowing managers to recolonize high-priority coho salmon streams with genetically appropriate stocks.

Project activities that would reduce the risk to coho salmon relative to baseline conditions are associated with operational modifications at the Mirabel and Wohler diversion facilities. Changes in project operations would improve conditions for migration by reducing the risk of impingement at both diversion facilities. Such changes would also provide escape for fish swept into the Wohler infiltration ponds during storm flows.

Several project components have the potential to continue to affect coho salmon. The Riverfront Park represents a low risk of entrapment because a few migrating juvenile or adult coho salmon may be entrapped in the lakes during high flows. Smaller risks of entrapment would occur at Spring Lake and the Mirabel and Wohler infiltration ponds. There is also the potential that juveniles could become stranded during inflation of the inflatable dam at Mirabel. Finally, sediment and vegetation maintenance in the constructed flood control channels on streams that support coho salmon (such as Santa Rosa Creek) may also negatively affect passage conditions during low flows.

For coho salmon, the benefits of the proposed project substantially outweigh the potential negative effects. The most substantial benefits would occur from the DCFH coho salmon supplementation program. The program proposes to raise coho salmon for release into the Russian River watershed to increase numbers and distribution of coho salmon. Additional benefits would result from habitat restoration efforts, and implementation of the Flow Proposal. Modifications to project facilities and operations reduce many existing risks to a low or negligible level. Cumulatively, the proposed project activities should help to halt declines in abundance of coho salmon in the Russian River and increase their distribution within the watershed.

Steelhead

Steelhead generally use the Upper and Middle Russian River mainstem and tributaries for spawning and rearing. Of the three species, steelhead are the most widespread in the basin and have the greatest potential to interact with project operations.

Project activities that would provide the greatest benefit to steelhead are the Flow Proposal, elimination of artificial breaching of the Estuary sandbar, habitat restoration projects in the Russian River, and modifications at the Mirabel and Wohler diversion facilities. Implementation of the Flow Proposal would improve juvenile rearing habitat in both the Russian River and Dry Creek by providing lower flows than under D1610. These lower flows would reduce the energetic expenditures required by juveniles to occupy their habitats, potentially resulting in better growth. Under the Flow Proposal, the sandbar in the Estuary would remain closed throughout the summer, which would improve rearing habitat in the Estuary. The instream restoration projects would help increase habitat complexity in the tributaries, which should increase the overall growth and survival rates of fry and juveniles in the watershed. Finally, structural and operational modifications at the Mirabel and Wohler diversion facilities would improve fish passage conditions over baseline, and would benefit steelhead rearing in the spring.

Several project components may continue to have a small negative effect on steelhead. Like coho salmon, a few migrating juveniles and/or adults could be entrapped during high flows in the Riverfront Park lakes, at Spring Lake, or in the Wohler and Mirabel infiltration ponds. There is also a small risk that rearing steelhead may become stranded during the inflation of the Mirabel dam. Finally, sediment and vegetation maintenance in the constructed flood control channels may affect some rearing habitat or impair passage in channels maintained for flood control purposes.

In general, implementation of the proposed project would significantly improve migration and rearing conditions for steelhead over baseline conditions and should help increase their abundance in the Russian River watershed.

Chinook Salmon

Primary Chinook salmon spawning and rearing occurs in the Russian River mainstem, selected larger tributaries such as Dry Creek, and the Estuary. Project components that affect the mainstem and Dry Creek overlap with Chinook salmon and their habitats. The proposed project is likely to have only small, localized effects on Chinook salmon upstream migration, spawning, and incubation. The lifestages most likely to be affected are juvenile rearing and downstream migration.

As with steelhead, modifications at the Mirabel and Wohler diversion facilities would benefit juvenile downstream passage. Structural and operational modifications at Coyote Valley Dam would benefit Chinook salmon rearing. Elimination of summertime artificial breaching of the sandbar at the river mouth would substantially reduce the risk that early adult spawners would enter the river before conditions in the river are suitable.

Ongoing operations and maintenance activities are likely to continue to have some negative effects. The most substantial effects to rearing habitat would occur from localized habitat alterations due to gravel-bar grading and vegetation removal in the mainstem Russian River. Localized effects could also occur to Chinook salmon from inflation of the dam at Mirabel, and potential entrapment in the Riverfront Park lakes.

With the proposed project, potential negative effects on Chinook salmon would be substantially reduced from baseline conditions. The benefits of the proposed project would outweigh any localized negative effects and should help recover Chinook salmon populations throughout the Russian River watershed.

Overall Project

On balance, the proposed project would benefit coho salmon, steelhead, and Chinook salmon populations in the Russian River, improve the quantity and quality of habitat, and reduce exposure to harmful activities. The improved conditions would benefit multiple lifestages, in both tributary and mainstem habitat. Some adverse effects associated with the project are unavoidable. Therefore, the proposed project may continue to adversely affect some salmonids or impair habitat in small, localized areas such as sediment management in constructed flood control channels. Some project activities may be essential to recovery, like the coho salmon captive broodstock program and stream restoration or barrier removal projects. Other project activities, like the recycled water program, will depend on the willingness of agricultural users to use recycled water in place of surface water from tributary streams. The proposed project provides balance between activities that would provide essential services like water supply and flood control and potential adverse effects to listed salmonids and to the ecosystem on which they depend. Overall, the proposed project would improve conditions for all three of the listed salmonids.

1.1 SECTION 7 CONSULTATION

The U.S. Army Corps of Engineers (USACE), the Sonoma County Water Agency (SCWA), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the federal Endangered Species Act (ESA) with National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries, formerly National Marine Fisheries Service [NMFS]). This Section 7 Consultation will evaluate the effects of operations and maintenance activities on listed salmonid species and their habitats in the Russian River watershed in northern California. The action agencies involved include USACE, SCWA, and MCRRFCD.

USACE, SCWA, and MCRRFCD activities span the Russian River from Coyote Valley Dam and Warm Springs Dam to the Russian River Estuary (Estuary) and several tributaries. The Russian River watershed supports threatened coho salmon (*Oncorhynchus kisutch*), steelhead (*Oncorhynchus mykiss*), and Chinook salmon (*Oncorhynchus tshawytscha*). USACE, SCWA, and MCRRFCD operate and maintain facilities and conduct activities related to flood control, water diversion and storage, instream flow releases, estuary management, hydroelectric power generation, channel maintenance, and fish production. In addition, these agencies are participants in a number of institutional agreements related to fulfilling their respective responsibilities.

The ESA requires federal agencies such as USACE to consult with secretaries of the U.S. Department of Interior and/or Commerce to ensure that their actions are not likely to jeopardize the continued existence of listed species or adversely modify or destroy critical habitat. USACE determined that their activities in the Russian River watershed may affect listed anadromous fish managed by NOAA Fisheries. Accordingly, USACE, SCWA, MCRRFCD, and NOAA Fisheries have entered into a Memorandum of Understanding (MOU) that sets a framework for the consultation on project activities that may directly or indirectly affect coho salmon, steelhead, and Chinook salmon in the Russian River. The MOU acknowledges the involvement of other agencies, including the California Department of Fish and Game (CDFG), the State Water Resources Control Board (SWRCB), the North Coast Regional Water Quality Control Board (NCRWQCB), the State Coastal Conservancy, and the Mendocino County Inland Water and Power Commission (MCIWPC).

1.2 SCOPE OF THE BIOLOGICAL ASSESSMENT

As part of the Section 7 Consultation, USACE, SCWA, and MCRRFCD have prepared this biological assessment (BA) for NOAA Fisheries that describes the actions subject to consultation, including the facilities, operations, maintenance, and existing conservation actions undertaken by the action agencies (USACE, SCWA, and MCRRFCD). The BA describes environmental baseline conditions, including information on hydrology, water quality, habitat conditions, and fish populations.

A major focus of the BA is the assessment of potential effects on listed fish species. The assessment considers potential effects from proposed new facilities. It also considers project operations and maintenance procedures for new and existing facilities. Project operations and maintenance evaluated in the BA and to be included in the biological opinion (BO) include the following:

- Flood Control Operations (Coyote Valley and Warm Springs dams);
- Hydroelectric Project Operations (Warm Springs Dam);
- Water Supply Operations at Coyote Valley and Warm Springs dams and operation of the diversion facilities (in and adjacent to the Russian River near Mirabel);
- Water Management (in Dry Creek and in the East Fork and mainstem Russian River);
- Estuary Management (at the mouth of the Russian River);
- Channel Maintenance (in the mainstem Russian River and tributaries);
- Restoration and Conservation Actions (throughout the watershed); and
- Fish Facility Operations (Coyote Valley Fish Facility [CVFF] at Coyote Valley Dam, and Don Clausen Fish Hatchery [DCFH] at Warm Springs Dam).

In addition to potential effects to listed fish species from project operations and maintenance, the BA must consider the effects of interrelated[1] and interdependent[2] activities. These are actions that depend on the project facilities for their operations. An example of an interrelated activity is sport harvest of hatchery-produced steelhead. Because the project produces hatchery steelhead for sportfishing, any effects to listed species from the harvesting activities targeting hatchery steelhead are related to the project. Anglers catching hatchery steelhead may, inadvertently, catch a wild steelhead. Although they are required to release the wild steelhead, the stress and potential mortality associated with the accidental capture are considered caused by the project activity.

The BA also considers potential cumulative effects from future nonfederal actions. Such actions are defined more narrowly under Section 7 Consultation than under the National Environmental Policy Act (NEPA), or under the California Environmental Quality Act (CEQA). Cumulative effects include the effects of state tribal, local, or private actions

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[1] An interrelated activity is “an activity that is part of the proposed project and depends on the proposed action for its justification” (USFWS and NMFS 1998).
[2] An interdependent activity is defined as “an activity that has no independent utility apart from the action under consultation” (USFWS and NMFS 1998).

that are reasonably certain to occur in the action area considered in the BO. Future federal actions that are unrelated to the proposed action are not considered in this section (USFWS and NMFS 1998). Many actions that have the potential to affect listed fish species or their habitats require federal permit or funding. The scope of cumulative actions focuses on state or private actions that are underway or are reasonably certain to occur within the time frame addressed by the BO.

The ESA prohibits the unauthorized "take"[3] of listed species. Take as defined under ESA includes harm to an individual. Therefore, in evaluating potential effects of project operations and maintenance activities, this document will find a conclusion of "likely to adversely affect" if any individual fish could be harmed by the proposed action, even if the risk of an adverse effect to the overall population is low. Such a conclusion will mean that one or more individual listed fish might be harmed by the proposed action. Incidental "take" may be authorized by NOAA Fisheries through issuance of an incidental take statement. Incidental take is take of a listed species that occurs as a result of conducting otherwise lawful activities that do not specifically target listed species.

The proposed project would have both beneficial and adverse effects on listed salmonids. However, the proposed project includes many changes to operation and maintenance that were made with the express purpose of reducing or eliminating project effects that were found in the evaluation of baseline conditions. The proposed project represents a substantial improvement over current operations. The USACE, SCWA, and MCRRFCD will develop a monitoring activities that would further refine some of the project operations to provide greater benefit to listed species and verify effectiveness of the measure to avoid injury to listed species.

When USACE submits a final BA to NOAA Fisheries, formal consultation under the ESA will be initiated. NOAA Fisheries will then prepare a BO for the proposed project. The BO will contain an assessment of the effects of the project on the listed fish species. NOAA Fisheries will evaluate the potential effects of the proposed project relative to baseline conditions to determine whether the activities of the proposed project are likely to jeopardize the continued existence of the populations under consultation. Their conclusion and supporting analysis will be presented in the BO. As a part of the BO, NOAA Fisheries will issue an incidental "take" statement to the USACE to cover "take" associated with the performance of USACE, SCWA, and MCRRFCD activities included in the project description. USACE is responsible for seeing that USACE, SCWA, and MCRRFCD comply with the incidental take statement, including adhering to take limits, reasonable and prudent measures, and its other terms and conditions.

In concert with development of the BO by NOAA Fisheries, the proposed project would undergo environmental review under both NEPA and CEQA, with the USACE and SCWA serving as the lead agency for their respective authorities. Changes in facilities and operations would be evaluated to determine whether the proposed project might have

[3] Take is defined as "to harass, harm, pursue, shoot, wound, kill, trap, capture, or collect, or to attempt to engage in any such conduct."

significant adverse impacts that should be mitigated, or whether an alternative action is more appropriate. Following environmental review, some elements of the proposed project would need additional state and federal permits before implementation could occur.

This BA presents the project description for activities undertaken by the USACE, SCWA, and MCRRFCD. It includes the ongoing operations and maintenance activities necessary for providing essential services to the communities in the Russian River watershed. It also includes a description of the new facilities and modifications to current operations and maintenance procedures that are being considered for implementation.

The proposed project analyzed in this BA includes both current water supply operations and potential future water supply operations that may be necessary to serve already-planned growth within the service area of SCWA's customers. As a basis for evaluating the potential impacts of future water supply operations, this BA assumes that SCWA will serve additional future water demands by constructing facilities and increasing diversions from the Russian River as contemplated by the Water Supply and Transmission System Project (WSTSP).[4]

Because of the California State Court of Appeal's decision on May 16, 2003, which upheld in part a challenge to the adequacy of the WSTSP Environmental Impact Report (EIR), SCWA must complete a supplemental environmental review of the program-level impacts of the WSTSP, and the SCWA Board of Directors must consider the analysis when determining whether to approve the WSTSP. Thus, although it is uncertain whether the WSTSP will be carried out as described in its original EIR, the inclusion of the proposed WSTSP in the present BA allows future impacts to the threatened salmonid species to be evaluated on more specific, defined assumptions than would otherwise be the case. The actual water supply facilities and diversions from the Russian River that the SCWA Board of Directors may approve in the future may differ from those contemplated in the WSTSP. Nevertheless, WSTSP provides a future model against which impacts to salmonids from future water supply development may be analyzed. Therefore, although approval of the WSTSP must be considered by the SCWA Board of Directors following completion of supplemental environmental review, a discussion of the WSTSP is included in this BA.

This BA provides a description of the environmental baseline associated with current project operations and with other activities that have affected habitat conditions in the Russian River, including agriculture, timber harvest, wastewater discharges, gravel mining, and urbanization. The BA includes proposed changes to operations and maintenance practices. A Draft BA was made available to the public on January 16, 2004, and presented to the Public Policy Facilitation Committee (PPFC) for agency and public review on February 6, 2004. After comments were received on the Draft BA, this Final BA was prepared and submitted to NOAA Fisheries. A proposed monitoring

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[4] The WSTSP project is described in an EIR prepared by SCWA (SCWA 1998a). The full citation can be found in Section 8.1 of this draft BA and is available in SCWA's offices in Santa Rosa, CA.

program and an implementation plan for the new facilities will be developed jointly with NOAA Fisheries.

Section 1, *Introduction*, presents the structure of the consultation as defined by the MOU, the regulatory history of the listings pertaining to salmon and steelhead in the Russian River, and a summary of the institutional agreements that govern activities addressed in the BA.

Section 2, *Baseline–Regional*, provides a description of the status of the listed species, their geographic distribution, and their habitat requirements. Section 2 also contains a description of the past and present actions including state, federal, local government, and private actions that are contemporaneous with the Section 7 Consultation.

Many of the facilities included in this consultation are already in place and operational. Section 3, *Baseline–Project,* contains a description of the facilities and their operations under the environmental baseline. This section presents baseline operations of project facilities and identifies effects of operation and maintenance activities on listed fish species.

Section 4, *Proposed Project Description*, presents a description of the proposed project under consideration, including operations and maintenance activities associated with project facilities and conservation actions directed toward improving environmental conditions. Where the proposed operations and maintenance actions are the same as those occurring under the baseline conditions, the descriptions in Section 3 are referenced. The descriptions of new facilities and changes in operation and maintenance practices are presented in Section 4. The changes in operations and maintenance and the additional facilities are proposed primarily to avoid injury to, or improve habitat conditions for, listed salmonids. During the development of the proposed modifications, a large number of alternatives were evaluated (ENTRIX, Inc. 2002c, 2003a). Many of these alternatives are discussed in Appendix A. Alternatives that were found to be either infeasible or unable to meet project objectives in the Alternatives Report (ENTRIX, Inc. 2002c, 2003a) were not considered in Appendix A.

Some of the modifications presented in Section 4 are underway or are being conducted on a trial basis. The description of the action indicates whether modifications are being currently implemented. Other modifications proposed in Section 4 are more conceptual and will require additional analyses and further refinement prior to implementation.

Section 5, *Potential Project Effects*, contains the effects analysis for the project actions described in Section 4 on coho salmon, steelhead, and Chinook salmon. The effects associated with each action are presented by species. The effects associated with the modified operations and proposed new facilities are compared to the effects identified under the baseline in Section 3. In addition to the evaluation of potential effects from the changes to project operations, the effects of ongoing operations and maintenance practices are also identified for each species and lifestage. The potential effects are evaluated and ranked relative to the degree of potential effect. Both direct and indirect effects of the proposed project are considered. Factors considered in the effects analysis include the relationship of the affected area to the species distribution, the affected life-history stage, the type of effect, the duration or frequency of the effect, and the response of the listed species to the effect.

Section 6, *Integration of Potential Effects*, reviews the effects noted in Section 5 and considers the activities in concert to determine the collective effect of project operations on each species. The examination of the collective effects of the proposed project includes the future direct and indirect effects from operations and maintenance, both positive and negative. It focuses on the species response to the effects at a population level.

Section 7, *Interrelated and Interdependent Actions and Cumulative Effects*, identifies and evaluates the effects of these activities. Activities considered interrelated or interdependent include potential effects to listed fish species related to water supply deliveries to SCWA's contractors and customers, recreational fisheries in the reservoirs, and fishing activities for hatchery-produced steelhead.

Section 7 also presents the effects of cumulative actions. Many of the planned future actions will require consultation under Section 7 of ESA, and therefore are not considered in this BA. Actions appropriate to consider in this BA are state actions with respect to future water rights. The SWRCB grants appropriative water-right permits and licenses for authorizing surface water diversions. This is a state action that is reasonably certain to occur and may affect listed species in the Russian River and its tributaries.

The next several sections of the BA provide additional information on the results of studies and other reports used in the preparation of the BA. This information is provided to increase the readers' understanding of the project, and to clarify the terms used in the document.

Section 8, *Literature Cited*, presents the references cited in the document and the information obtained from personal communications with other individuals.

Section 9, *Glossary*, provides definitions of technical terms used in the document.

Section 10, *Photo Tour*, provides photos of the facilities and project features.

The Appendices include supplemental information to the BA. Appendix A, *Alternative Actions*, presents an evaluation of alternative actions that were considered, but not proposed, for inclusion as part of the project description. Appendix B, *Flow Proposal* for *the Russian River,* includes additional information on the Flow Proposal and the permit terms that would be requested for the water-right permits held by SCWA. Appendix C, *Evaluation Criteria*, presents the information on the evaluation criteria used in the effects analysis. Appendix D, *Preliminary Recreational Analysis for the Flow Proposal*, and Appendix E, *Preliminary Economic Analysis for the Flow Proposal*, include supplemental studies conducted to assist in the development and evaluation of the alternative scenarios for managing instream flows in the Russian River and Dry Creek. Appendix F, *Flow-Habitat Assessment Study,* reports the results of the interagency study to evaluated habitat conditions at several flows in Dry Creek and the Upper Russian River.

1.2.1 Project Area

The project area includes the Russian River from Coyote Valley Dam downstream to the Russian River Estuary, Dry Creek from Warm Springs Dam to the mouth, and a number of smaller tributaries of the Russian River in Sonoma County (Figure 1-1).

Project operations related to Warm Springs Dam, Coyote Valley Dam, and water diversion facilities directly affect flows in the mainstem Russian River and in Dry Creek. Project operations related to channel maintenance and restoration and conservation actions may affect tributaries to the Russian River.

The watersheds upstream of Warm Springs Dam and Coyote Valley Dam were not included in the ESA listing and are not part of the project-affected area considered in this BA. A short reach of the East Fork, downstream of Coyote Valley Dam, is also affected by project operations.

To facilitate the analysis of potential effects, the project area has been subdivided into several geographic regions defined within the project area (Table 1-1). The Russian River has been divided into four major reaches—the Upper, Middle, and Lower Russian River—and, for this report, the Estuary is considered a fourth reach of the river.

Table 1-1 Russian River Watershed Regions

Region	Description
East Fork	Includes a short stretch of river downstream of Coyote Valley Dam to the confluence with the Russian River. The confluence of the Russian River and the East Fork is commonly referred to as "the Forks."
Mainstem	Includes the main channel of the Russian River. The mainstem can be divided into four reaches: Upper, Middle, Lower, and Estuary.
Upper Reach	Includes the mainstem of the Russian River between the Forks near Ukiah downstream to Cloverdale.
Middle Reach	Includes the mainstem of the Russian River from Cloverdale to the confluence with Dry Creek near Healdsburg.
Lower Reach	Includes the mainstem of the Russian River downstream of its confluence with Dry Creek, excluding the Mark West Creek watershed. Most tributaries to this region enter the river from the northwest. Flow and water quality modeling results are presented for two stations in this reach, Below Dry Creek and Hacienda
Estuary	Includes the mainstem of the Russian River from the river mouth, located near the town of Jenner, to approximately 6 to 7 miles upstream in the Duncans Mills and Austin Creek areas. Occasionally, tidal influence occurs as far as 10 miles upstream to Monte Rio. Willow Creek Marsh occasionally receives saltwater influence.

Table 1-1 Russian River Watershed Regions (Continued)

Region	Description
Dry Creek Watershed	Includes Dry Creek and all of its tributaries between Warm Springs Dam to the confluence with the Russian River. The Dry Creek watershed is the major sub-basin on the western side of the Middle Reach of the Russian River. Flow and water quality modeling results are presented for two stations in Dry Creek, Below Warm Springs Dam and Lower Dry Creek
Mark West Creek Watershed	Includes Mark West Creek, the Laguna de Santa Rosa, Santa Rosa Creek, and their tributaries. The Mark West Creek watershed is southeast of the Russian River. The cities of Santa Rosa and Windsor are in this region. The Laguna de Santa Rosa is south of Mark West Creek and includes the cities of Rohnert Park, Sebastopol, Cotati, and Santa Rosa.

1.2.2 Consultation to Date

USACE, SCWA, and NOAA Fisheries entered into an MOU on December 31, 1997, to establish a framework for the ESA Section 7 Consultation. The MOU created three committees to assist the USACE and SCWA with the Section 7 Consultation. The Executive Committee, composed of managers for USACE, SCWA, NOAA Fisheries, CDFG, and Mendocino County, provides guidance to the overall process. The Agency Working Group, (AWG), a technical work group that includes staff from USACE, SCWA, NOAA Fisheries, CDFG, and NCRWQCB provides technical review of the draft products. The third committee, the PPFC, includes county supervisors and managers of state and federal agencies. The role of the PPFC is to provide a conduit to the general public, where reports and analyses can be disseminated and comments and information can be received. Beginning in April, 1998 to date, the PPFC has held eighteen meetings, and has discussed the project products and alternative actions for project operations.

A series of interim reports evaluated effects of USACE, SCWA, and MCRRFCD operations on coho salmon, steelhead, and Chinook salmon under baseline conditions. Draft interim reports were submitted to the AWG and Executive Committee for review and comment. The interim reports were presented before the PPFC and public comments were taken. The interim reports included:

- *Interim Report 1: Flood Control Operations at Coyote Valley and Warm Springs Dams* (ENTRIX, Inc. 2000a)
- *Interim Report 2: Fish Facility Operations* (FishPro and ENTRIX, Inc. 2000)
- *Interim Report 3: Flow-Related Habitat* (ENTRIX, Inc. 2002b)
- *Interim Report 4: Water Supply and Diversion Facilities* (ENTRIX, Inc. 2001d)
- Interim Report 5: Channel Maintenance (ENTRIX, Inc. 2001b)

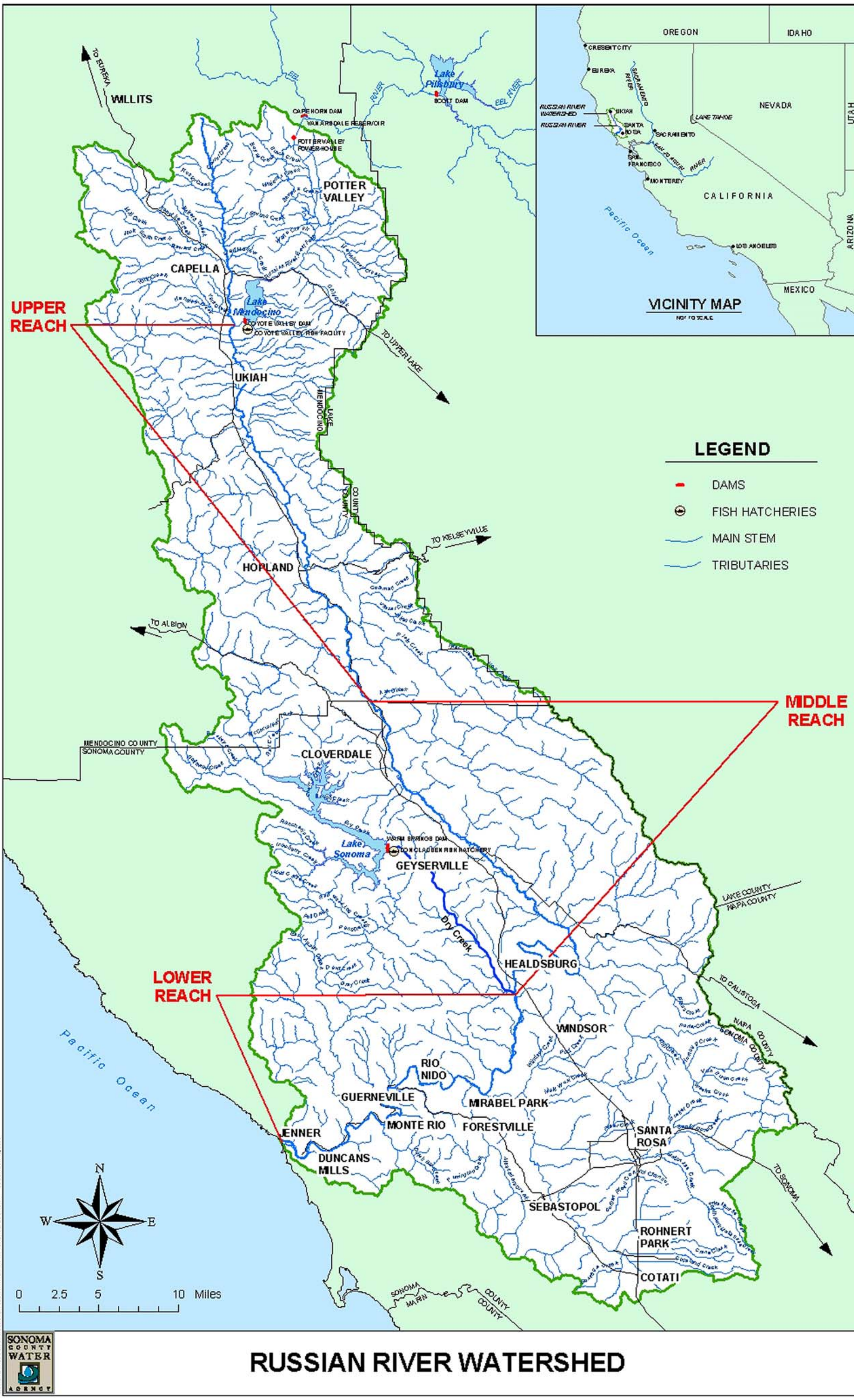

Figure 1-1 Map of the Russian River Watershed and Location of Reach Boundaries

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- *Interim Report 6: Restoration and Conservation Actions* (ENTRIX, Inc. 2001c)

- *Interim Report 7: Hydroelectric Projects Operations* (ENTRIX, Inc. 2000b)

- *Interim Report 8: Russian River Estuary Management Plan* (ENTRIX, Inc. 2001a)

Additional documents developed for the evaluation of the hatchery operations include:

- *Hatchery and Genetic Management: Monitoring and Evaluation Plan and Benefit Risk Analyses for Russian River Fish Production Facilities* (FishPro and ENTRIX, Inc. 2002)

- Hatchery and Genetic Management Plans for Russian River Fish Production Facilities, Coho Salmon and Steelhead (FishPro and ENTRIX, Inc. 2003)

Based on effects identified in these analyses, a list of alternative actions was developed to reduce adverse effects to listed species. Potential effects of alternative actions were evaluated in *Alternatives: Evaluation of Management Actions* (ENTRIX, Inc. 2002c). This report was presented to the AWG, the Executive Committee, and the PPFC for comment. Alternatives for flow management in the Russian River were considered in more detail in an addendum to the alternatives report (ENTRIX, Inc. 2003a).

Part I of the BA was released in June 2003. This document compared information on the first four sections of the BA: the institutional constraints, baseline environment, baseline project operations, and the proposed project, including the operation of SCWA's existing facilities. The Draft BA was made available to the public on January 16, 2004.

Previous ESA actions related to listed salmonids on USACE activities in the Russian River watershed are summarized below.

- July 1997. NOAA Fisheries. Biological Assessment for the Repairs of the Emergency Water Supply Line (EWSL) at Warm Springs Dam, California.

- August 22, 1997. NOAA Fisheries. Letter. Emergency Consultation for EWSL.

- September 30, 1997. NOAA Fisheries issued to USACE a BO and incidental take statement for repair work on the EWSL at Warm Springs Dam and the annual pre-flood inspection at Warm Springs Dam.

- November 1997. USACE submitted to NOAA Fisheries a supplement to its July 1997 BA for a vibration analysis test on Warm Springs Dam outlet works. Due to safety concerns, the testing proceeded without a BO. NOAA Fisheries protested additional tests performed by USACE in March 1998.

- November 25, 1997. U.S. Army Corps of Engineers. Letter. Request Section 7 Consultation for EWSL testing.

- January 8, 1998. NOAA Fisheries. Letter. Consultation for EWSL.

- January 21, 1998. U.S. Army Corps of Engineers. Letter. Formal Consultation for EWSL.

- January 28, 1998. NOAA Fisheries. Letter. Consultation for EWSL.

- March 24, 1998. NOAA Fisheries. Letter. Recommended interim ramping rates.

- April 13, 1998. NOAA Fisheries. Letter. Vibration Testing.

- April 23, 1998. U.S. Army Corps of Engineers. E-mail. Proposal to fix and reinstall damaged flashboards at Warm Springs Dam.

- April 24, 1998. NOAA Fisheries. E-mail. Concurrence and ramping rates for flashboard repairs.

- June 17, 1998. NOAA Fisheries. Letter. Vibration Analysis.

- July 1998. U.S. Army Corps of Engineers. Biological Assessment. Periodic Inspections for Warm Springs Dam, Sonoma County and Coyote Valley Dam, Mendocino County.

- July 22, 1998. NOAA Fisheries. Letter. Scheduling of Periodic Inspections.

- July 24, 1998. U.S. Army Corps of Engineers. Letter. Request Section 7 Consultation for Periodic Inspections.

- July 27, 1998. NOAA Fisheries. Letter. Periodic Inspections.

- August 21, 1998. U.S. Army Corps of Engineers. Letter. Periodic Inspections.

- September 4, 1998. NOAA Fisheries issued to USACE a BO and incidental take statement for periodic inspections at Warm Springs Dam and Coyote Valley Dam.

- November 3, 1998. NOAA Fisheries. Letter. Stream Monitoring Survey Results performed by NOAA Fisheries staff.

- November 4, 1998. NOAA Fisheries. Letter. Consultation prior to flood season activities.

- November 17, 1998. U.S. Army Corps of Engineers. Letter. Submission of Biological Assessment for Flood Control Operations of Coyote Valley Dam, Mendocino County and Warm Springs Dam, Sonoma County Russian River Basin, California.

- December 4, 1998. U.S. Army Corps of Engineers. Letter. Proposal to remove flashboards from stilling basin at Warm Springs Dam.

- December 9, 1998. U.S. Army Corps of Engineers. Letter. Supplemental information for proposal to remove flashboards from stilling basin at Warm Springs Dam.

- December 9, 1998. NOAA Fisheries. NLAA Determination. Flashboard Removal at Warm Springs Dam. December 9, 1998.

- February 2, 1999. U.S. Army Corps of Engineers. Letter. Request change of NLAA determination.

- February 3, 1999. NOAA Fisheries. NLAA Determination. Flashboard Removal at Warm Springs Dam.

- May 1999. U.S. Army Corps of Engineers. Biological Assessment. Flood Control Operations of Coyote Valley Dam, Mendocino County, and Warm Springs Dam, Sonoma County, Russian River Basin, California. Incorporates the monitoring reports and recommendations from the most recent pre-flood inspections, maintenance activities and 5-year periodic inspection.

- May 4, 1999. U.S. Army Corps of Engineers. Letter. Pre-Flood Inspections and Dam Safety Repairs for Coyote Valley Dam and Warm Springs Dam in the Russian River Basin.

- May 17, 1999. U.S. Army Corps of Engineers. Letter. Additional Information Coyote Valley Pre-Flood Inspection.

- June 1999. NOAA Fisheries issued to USACE a BO and incidental take statement for pre-flood inspections at Warm Springs Dam and Coyote Valley Dam.

- June 10, 1999. NOAA Fisheries. Amendment to Biological Opinion for Pre-flood Inspections at Coyote Valley Dam and Warm Springs Dam 1999.

- February 22, 2000. U.S. Army Corps of Engineers. Emergency Inspection of EWSL at Lake Sonoma/Warm Springs Dam Project.

- February 23, 2000. NOAA Fisheries issued to USACE a letter of concurrence with a proposed action for emergency repairs to the EWSL at Warm Springs Dam.

- March 17, 2000. U.S. Army Corps of Engineers. Letter. Pre-Flood Inspections and Dam Safety Repairs for Coyote Valley Dam and Warm Springs Dam in Russian River Basin.

- May 9, 2000. NOAA Fisheries. Biological Opinion. Pre-Flood Inspections and Dam Safety Repairs for Coyote Valley Dam and Warm Springs Dam in the Russian River Basin.

- May 11, 2000. U.S. Army Corps of Engineers. Pre-Flood Inspection Report – Observations and Lessons Learned.

- July 6, 2000. U.S. Army Corps of Engineers. Rescheduling of FY 2000 Pre-Flood Inspection/Gate Testing for Coyote Valley Dam and Sonic Meter Installation at Warm Springs Dam.

- September 22, 2000. NOAA Fisheries issued to USACE a letter of not likely to adversely affect federally-listed species or habitat for reductions in flow to 25 cfs below Warm Springs Dam and Coyote Valley Dam during EWSL repairs at Warm Springs Dam and pre-flood inspections at Coyote Valley Dam.

- September 22, 2000. NOAA Fisheries issued to USACE a letter of not likely to adversely affect federally-listed species or habitat for reduction in flow at Warm Springs Dam during sonic meter installation at Warm Springs Dam.

- October 11, 2000. NOAA Fisheries issued to USACE a BO for inspection and gate testing at Coyote Valley Dam.

- November 2000. U.S. Army Corps of Engineers. Results of the USACE, NOAA Fisheries, and SCWA Interagency Stream Survey Report for Pre-Flood Inspections.

- August 27, 2001. NOAA Fisheries issued to USACE a letter of not likely to adversely affect federally-listed species or habitat for pre-flood inspection and repair of the outlet conduit at Warm Springs Dam.

- September 20, 2001. NOAA Fisheries issued to USACE a BO for a pre-flood inspection at Coyote Valley Dam and inspection of City of Ukiah repairs to a bifurcation plate in the plenum chamber.

- September 25, 2001. SCWA, USACE, and NOAA Fisheries 2001 Field Notes and Flow Data Charts.

- October 27, 2001. NOAA Fisheries. Concurrence with NLAA Determination. FY 2001 Pre-Flood Inspections for Warm Springs Dam.

- March 28, 2002. U.S. Army Corps of Engineers. Pre-Flood Inspections for Warm Springs Dam.

- August 14, 2002. NOAA Fisheries issued to USACE a letter of not likely to adversely affect federally-listed species or habitat for pre-flood inspection at Warm Springs Dam.

- August 22, 2002. U.S. Army Corps of Engineers. FY 2002 Pre-Flood Inspections and Dam Safety Repairs for Coyote Valley Dam in the Russian River Basin.

- September 25, 2002. NOAA Fisheries issued to USACE a BO for pre-flood inspection at Coyote Valley Dam and repair work conducted by the City of Ukiah.

- September 26, 2002. SCWA, USACE, and NOAA Fisheries 2002 Field Notes and Flow Data Charts.

- November 27, 2002. Sonoma County Water Agency. Flow Measurements from Coyote Valley Dam Pre-flood Inspections.

- June 13, 2003. Draft Biological Assessment – Russian River Part I, ENTRIX, Inc.

- June 25, 2003. U.S. Army Corps of Engineers – Periodic Inspections for Warm Springs Dam.

- July 2003. U.S. Army Corps of Engineers – Preflood Survey Results 2001-2002.

- July 22, 2003. NOAA Fisheries. NOAA Concurrence Letter for Periodic Inspections at Warm Springs Dam.

- August 6, 2003. U.S. Army Corps of Engineers – Periodic Inspection Reschedule for Warm Springs Dam.

1.2.3 Recovery Plans in the Project Area

No federal recovery plans have been completed for Russian River anadromous fish. Section 4(f) of the ESA requires NOAA Fisheries to develop and implement recovery plans for the conservation and survival of threatened and endangered species. Recovery plans for Central California Coast (CCC) coho salmon, CCC steelhead, and California Coastal Chinook salmon are underway. All three species are included in the CCC recovery planning domain. A Technical Recovery Team (TRT) has been convened to begin development of a recovery plan for the CCC that includes the Russian River stocks. The TRT is in the process of identifying independent populations of the three species included in the recovery domain.

1.3 Regulatory Status of Listed Fish Species in the Russian River

Biological resources of primary concern within the project area are coho salmon, steelhead, and Chinook salmon. Coho salmon and steelhead are native Russian River species, although there have been many introductions from other river systems (CDFG 1991). It is uncertain whether Chinook salmon is a native species of the Russian River (NMFS 1999c). They have not been stocked since 1998 and continue to reproduce in the watershed. The naturally-spawning Chinook salmon are considered part of the California Coastal Chinook salmon population, which is protected under the ESA.

Coho salmon, steelhead and Chinook salmon in the Russian River are each listed as threatened under the ESA. The listing process evaluates whether or not a species is vulnerable to extinction. There are two levels at which species are listed: threatened or endangered. An “endangered” species is one that is in danger of extinction throughout all, or a significant portion, of its range. A “threatened” species is one that is likely to become endangered in the foreseeable future. The listing process goes though a careful review of the geographic distribution, abundance levels, condition of the available habitat, threaten destruction or modification of habitat, and other natural or manmade factors affecting its continued existence. This analysis was completed for the populations that include the Russian River stocks. The determination at that time was that the populations were likely to become endangered in the foreseeable future and should be listed as threatened.

Once a species has been listed, NOAA fisheries periodically, conducts a status review to determine if the abundance levels of the listed population have changed, or if the risk factors affecting the listed population have changed. NOAA Fisheries is currently conducting a status review of populations that include the Russian River stocks. In the draft status review CCC steelhead and California Coastal Chinook salmon is proposed to continue to be listed as threatened. CCC coho salmon is proposed to be upgraded to “endangered” because abundance data show that numbers continue to decline and risk factors that threaten habitat continue to increase (NOAA Fisheries 2003a).

The pertinent Federal Register (FR) notices for these species are provided in Table 1-2.

Table 1-2 Federal Register Notices for the Salmonids of the Russian River

Species	Listing	Take Prohibitions	Critical Habitat
Coho Salmon	Vol. 61, No. 212, pp. 56138-56147 Oct. 31, 1996	Vol. 67, No. 6, pp. 1116-1133 January 9, 2002	Vol. 64, No. 86, pp. 24049-24062 May 5, 1999
Steelhead	Vol. 62, No. 159, pp. 43937-43954 Aug. 18, 1997	Vol. 65, No. 132, pp. 42422-42481 July 10, 2000	Vol. 65, No. 32, pp. 7764-7787 February 16, 2000
Chinook Salmon	Vol. 64, No. 179, pp. 50394-50415 Sept. 16, 1999	Vol. 67, No. 6, pp. 1116-1133 January 9, 2002	Vol. 65, No. 32, pp. 7764-7787 February 16, 2000
Steelhead and Chinook Salmon			Vacated by April 30, 2002 court order[1] Vol. 68 No. 188 p. 55900 September 29, 2003

[1] Critical habitat designations vacated by National Association of Home Builders v. Donald L. Evans, Civil Action No. 00-2799 (CKK) (District Court, District of Columbia).

NOAA Fisheries designated the Russian River and its tributaries as critical habitat for steelhead and Chinook salmon (as described in the following sections). However, on March 11, 2002, NOAA Fisheries submitted a proposed settlement agreement in U.S. District Court to rescind current critical habitat designations for 19 Evolutionarily Significant Units (ESUs), which included coho salmon, steelhead, and Chinook salmon populations in the Russian River basin. The court accepted the settlement proposed and remanded critical habitat designation to the NOAA Fisheries for reconsideration. NOAA Fisheries is conducting a new, more thorough analysis of the economic effects from designation of critical habitat. NOAA Fisheries is expected to proceed with re-issuing critical habitat designations after that analysis is complete.

For the BA, the evaluation of critical habitat described by NOAA Fisheries in the original critical habitat designations will be used to guide the evaluation of potential effects on habitat. The goal of regulation of critical habitat is to preserve habitat elements essential to the continued existence of the species. By using the approach outlined in the original critical habitat designation, the effects of the proposed project on habitat important to listed salmonids will be considered.

1.3.1 Central California Coast Coho Salmon (*Oncorhynchus kisutch*)

The CCC coho salmon ESU consists of all naturally-spawned coho salmon populations from Punta Gorda (Humboldt County) south through the San Lorenzo River (Santa Cruz County), and includes coho salmon populations in the Russian River. This ESU also includes tributaries to San Francisco Bay, excluding the Sacramento-San Joaquin River system.

The critical habitat for the CCC coho ESU encompasses all accessible river reaches within the ESU (i.e., from Punta Gorda south to the San Lorenzo River). Critical habitat consists of all waterways, substrate, and adjacent riparian zones below long-standing, naturally-impassable barriers (i.e., natural waterfalls in existence for at least several hundred years). Adjacent riparian zones were defined on the basis of functional criteria rather than quantitative criteria. Specifically, the adjacent riparian zone is the area adjacent to a stream that provides the following functions: shade, sediment, nutrient or chemical regulation, streambank stability, and input of large woody debris or organic matter. Areas specifically excluded from critical habitat included historically-occupied habitat upstream of specific dams identified in the FR notice (including Warm Springs Dam and Coyote Valley Dam), and Indian tribal lands.

1.3.2 Central California Coast Steelhead (*Oncorhynchus mykiss*)

The CCC steelhead ESU consists of steelhead occupying the Russian River and all river basins south to Aptos Creek in Santa Cruz County (inclusive). The CCC steelhead ESU also occupies drainages of San Francisco and San Pablo bays, eastward to the Napa River (inclusive), but not including the Sacramento-San Joaquin River basin. The Russian River is the largest drainage in the CCC steelhead ESU. Steelhead reared at the DCFH were specifically excluded from the listed ESU in the final rule.

Original critical habitat for CCC steelhead encompassed the current freshwater and estuarine range inhabited by the ESU (i.e., from the Russian River south to Aptos Creek). Critical habitat consisted of all waterways, substrate, and adjacent riparian zones below long-standing, naturally-impassable barriers. As with coho salmon, habitat excluded from critical habitat included river reaches upstream of several dams that block access to former anadromous habitats (including Warm Springs Dam and Coyote Valley Dam), and Indian tribal lands.

1.3.3 California Coastal Chinook Salmon (*Oncorhynchus tshawytscha*)

The California Coastal Chinook salmon ESU consists of naturally-spawned populations from Redwood Creek in Humboldt County south through the Russian River (inclusive).

Hatchery populations are not considered essential for the recovery of the ESU and, therefore, are not listed at this time. In the final rule, NOAA Fisheries excluded Chinook salmon raised at DCFH from the California Coastal ESU. The Russian River basin presently contains the southernmost persistent population of Chinook salmon on the California coast.

The original critical habitat for the California Coastal Chinook ESU encompassed accessible reaches of all rivers (including estuarine areas and tributaries) within the current range inhabited by the ESU (i.e., from Redwood Creek in Humboldt County south through the Russian River). The critical habitat defined for Chinook salmon recognized the same exclusions as coho salmon and steelhead.

1.4 INSTITUTIONAL AGREEMENTS AND CONSTRAINTS

USACE, SCWA, and MCRRFCD conduct activities and operate facilities included in the Section 7 Consultation under regulatory constraints and existing agreements, contracts, and vested property rights involving state, local, and federal entities, as well as individual property owners. Some agreements may constrain the extent to which, absent regulatory approvals and/or changes to the agreements, USACE, SCWA, and MCRRFCD can implement the conservation measures, reasonable and prudent measures, and conservation recommendations developed by NOAA Fisheries in the BO for the consultation. Implementation of the Flow Proposal by USACE and SCWA would also require additional regulatory approvals prior to implementation. This section describes the existing agreements that pertain to activities under consideration in this consultation.

1.4.1 POTTER VALLEY PROJECT

Much of the water that flows from the East Fork Russian River into Lake Mendocino originates in the Eel River watershed. Starting in 1908, water has been diverted from the Eel River to the East Fork Russian River through a tunnel to the hydroelectric plant. Now operated by Pacific Gas and Electric Company (PG&E), the project is called the Potter Valley Project (PVP). Scott Dam, forming Lake Pillsbury, began operating in 1922 to provide water to the project through the summer.

In 1965, SCWA entered into an agreement with PG&E in anticipation of the Federal Energy Regulatory Commission (FERC) considering the relicensing of the PVP upon the expiration of PG&E's 50-year license to generate power (FERC Project No. 77). This agreement acknowledges that the continued operation of the PVP is important to the successful operation of the Coyote Valley Dam Project (CVDP) and SCWA's water transmission system. The agreement provides for the parties "cooperating in the public interest to secure, insofar as may be possible, such continuation of operation." Under the agreement, SCWA is obligated to maintain riverbanks and a series of 15 check-dam structures (which were constructed as part of the PVP along the East Fork Russian River between the Potter Valley powerhouse and Lake Mendocino).

Article 39 of the existing FERC-issued PVP license required a 10-year study of the effects of the project operations on downstream fish resources and provided for FERC consideration of changes to the required minimum Eel River flows. The minimum flows at issue are those necessary to protect and maintain anadromous salmon and steelhead trout populations in the Eel River. In February 1999, FERC issued a draft environmental impact statement (DEIS) for its planned reconsideration of Eel River minimum streamflows required downstream of the PVP. In May 2000, FERC issued a final environmental impact statement (FEIS). The FEIS evaluated the four alternatives addressed in the DEIS, and proposed a recommended flow regime.

In November 2002, NOAA Fisheries issued a final BO pursuant to the FERC action, which concluded that the recommended alternative in the FEIS would pose jeopardy to threatened salmonids in the Eel River. FERC action is pending on the requests for the preparation of a supplement to the FEIS and proposed modification to the recommended Flow Proposal. FERC has not yet made a final decision on a license amendment to establish new Eel River minimum streamflow requirements for the PVP. The outcome of these decisions may affect the quantities of water diverted from the Eel River to the East Fork Russian River in the future.

1.4.2 Russian River Project

The Russian River Project was initiated to control flooding and develop water resources and recreational opportunities in the Russian River basin. The Russian River Project is a water diversion and storage project operated by SCWA and USACE to furnish water from the Russian River, the East Fork Russian River, and Dry Creek for domestic, industrial, municipal, irrigation (Lake Mendocino and Russian River water only), and recreational use. The Russian River Project consists of a number of elements, including Coyote Valley Dam and Warm Springs Dam, associated channel stabilization works, recreational facilities, and fish production facilities to mitigate and enhance fisheries in the basin.

1.4.2.1 Coyote Valley Dam Project

On November 15, 1949, USACE issued and filed with Congress a report recommending the construction of Coyote Valley Dam. In response, the California legislature created the Sonoma County Flood Control and Water Conservation District (later renamed the Sonoma County Water Agency) and the Mendocino County Flood Control and Water Conservation District (later renamed the Mendocino County Water Agency). Under this legislation authorizing construction of the dam, these agencies were to provide the local cooperation and funding required to construct the dam. The state legislation authorizing the formation of the local entities included a procedure to establish a more localized district (specific to the Russian River basin), which was established in 1956 as the Mendocino County Russian River Flood Control and Water Conservation Improvement District.

The CVDP was authorized by Section 204 of the federal 1950 Flood Control Act and described in House Document Number 585 by the 81st Congress. The Flood Control Act approved the plan in the Russian River basin for flood control and water conservation. The act appropriated $11.522 million for the initial stage of the plan and required that, prior to starting construction, local interests contribute $5.598 million to pay for the conservation benefits (i.e., water supply) resulting from the project.

Public Law 404, approved February 10, 1956, authorized an additional $1.165 million federal appropriation toward the completion of the initial stage of the CVDP. In March 1956, SCWA made the required cash contribution in accordance with the authorizing act. In December 1956, the MCRRFCD reimbursed SCWA $633,000 for a share of the water supply capacity of the reservoir. These payments satisfied the entire local cost-sharing obligation for the CVDP, except for the obligation to maintain erosion control measures. These measures were constructed as part of the CVDP at 91 locations along the Russian River from Calpella to Healdsburg.

The CVDP began storing water in 1958, and all facilities were completed in 1959. No formal written contract exists that defines the respective rights and obligations of USACE, SCWA, and MCRRFCD regarding the CVDP. These rights and obligations are, however, documented in the legislation and various other writings. Such documentation includes resolutions of assurances by SCWA’s Board of Directors, USACE’s Water Control Manual for the CVDP (USACE 1984), as well as decisions of SWRCB (discussed in Section 1.4.3). Other components of the CVDP, which include hydroelectric projects, flood control structures in Mendocino and Sonoma counties, and fish production facilities, are described below.

City of Ukiah Hydroelectric Project FERC License

The City of Ukiah filed an application to FERC for a major license under Part 1 of the Federal Power Act on April 13, 1981, to construct, operate, and maintain the Lake Mendocino Power Project No. 2841. The FERC license was issued April 1, 1982 (FERC 1982) and will be in effect for 50 years. Additionally, USACE issued a license to the City of Ukiah on April 1, 1982 for the use of land and facilities incidental to the construction and operation of the hydroelectric project. Construction of the hydroelectric plant was completed in December 1986. It has a total generation capacity of 3.5 megawatts (MW) through two turbine and generator units.

Two problems had to be overcome in the development of the project. First, the outlet works needed to be retrofitted to withstand the full hydrostatic pressure of Lake Mendocino. Also, a bifurcation with an appropriate valve configuration needed to be installed to permit flows to bypass the turbine. Second, concerns about the dissolved oxygen (DO) content of water passing through the turbine resulted in a requirement to construct oxygenation facilities at the outlet. The terms of the FERC license dictate project operations including release of suitable bypass flows meeting water quality standards to maintain fish and wildlife habitat downstream during operations and maintenance of the hydroelectric facility.

Russian River Flood Control in Mendocino County

Coyote Valley Dam is the primary flood control facility on the upper Russian River. The dam is located on the East Fork Russian River approximately 3 miles northeast of the

City of Ukiah. Coyote Valley Dam forms Lake Mendocino, which has a design capacity of approximately 122,500 acre-feet (AF) and drains an area of approximately 105 square miles, or approximately 7 percent of the total Russian River basin (USACE 1986b). USACE controls flood releases from Coyote Valley Dam according to USACE's Water Control Manual detailing operational methods (USACE 2003a).

When Coyote Valley Dam was constructed, USACE recognized that flood control releases from Lake Mendocino would result in long-term bankfull flows, which would aggravate bank erosion. To offset potential erosion, USACE constructed stabilization works in the upper Russian River. These works were the first publicly-owned flood control facilities in the upper Russian River and were acquired by MCRRFCD as easements for the construction and maintenance of channel stabilization works associated with the Coyote Valley Dam.

The channel stabilization works constructed by USACE in Mendocino County consisted principally of rock riprapped levees, earth levees, pile and wire revetments, steel jacks, and various other types of bank protective works. These were constructed at intermittent sites along a 15-mile reach of the Russian River extending from approximately 5 miles north of Hopland to Calpella between 1956 and 1963. The MCRRFCD maintains these works under an agreement with USACE according to specifications identified in a Mendocino County operation and maintenance manual (O&M manual) developed in 1965 (USACE 1965a).

Russian River Channel Maintenance in Sonoma County

The first channel stabilization works constructed by USACE in Sonoma County were transferred to SCWA for maintenance in November 1962. The works constructed along the Russian River included channel clearing, pilot channels, bank protection works consisting of anchored steel jacks, flexible fence training structures, and wire mesh-gravel revetments. These installations were made in 41 different locations in the Alexander Valley.

To permit the construction of erosion control works, SCWA acquired easements from most of the property owners from just south of the old Preston Bridge north of Cloverdale, to a point approximately 4 miles downstream from the Alexander Valley Bridge. These acquisitions began in 1962. Over the next 10 years, USACE performed extensive bank protection and repairs within SCWA easements.

During this period, SCWA also sponsored the restoration of flood control works constructed by nonfederal interests in the upper Russian River. This restoration work was performed pursuant to Public Law 84-99 administered by USACE. SCWA provided 20 percent of the construction cost for these projects, either through direct funding or in-kind services. SCWA also agreed to provide necessary easements, which generally had already been acquired, and to hold and save the federal government free from damages.

Since 1972, SCWA has been responsible for maintaining the USACE channelization works associated with CVDP. SCWA is required to maintain these works in Sonoma

County following specifications identified in a Sonoma County O&M manual (USACE 1965b).

Coyote Valley Fish Facility

Before the completion of Coyote Valley Dam, it was believed that the higher streamflows resulting from operation of the project would mitigate for the loss of spawning and rearing habitat above the dam. After the project had been in operation, it became evident that the anticipated benefits (i.e., improved rearing habitat) would not be realized.

The Water Resources Act of 1974 enacted Section 95 of Public Law 93-251, which directed USACE to compensate for fish losses on the Russian River attributed to the operation of Coyote Valley Dam facilities in Mendocino County. This mitigation was accomplished, in part, by modification and expansion of the fish hatchery at Warm Springs Dam. The construction of the fish facility at Coyote Valley Dam and expansion of the DCFH facilities began in 1991 and both were operational by 1992. The mitigation program involves capturing returning adult steelhead at CVFF, collecting eggs and fertilizing them, then transporting the fertilized eggs to the DCFH for incubation and rearing to yearling size. These fish are then returned to CVFF for imprinting and release.

Currently, CDFG operates both DCFH at Warm Springs Dam and CVFF at Coyote Valley Dam under Cooperative Agreement DACW05-82-A-0066 as amended September 30, 1991 (USACE and CDFG 1991). The period of this agreement began in October 1991 and extended through September 1999. Yearly extensions have been granted to CDFG since 1999.

1.4.2.2 Warm Springs Dam Project

The Warm Springs Dam Project (WSDP), including downstream channel improvements, was authorized by Section 203 of the federal Flood Control Act of 1962 and described in House Document 547 by the 87th Congress. A contract between the federal government and SCWA for water storage space in Lake Sonoma was entered into in December 1964 and was amended on October 1, 1982. Under this contract, SCWA is obligated to repay the federal government the full cost of the joint-use facilities allocated to water conservation (i.e., water supply). SCWA must also pay its pro-rata share of the annual operation and maintenance costs of the WSDP. SCWA’s share of these costs is funded through a property tax assessment on lands in Sonoma County and payments from water districts in Marin County that receive water from SCWA. The costs of operating and maintaining the fish production facility and recreation facilities at Warm Springs Dam/Lake Sonoma are borne by the federal government.

Warm Springs Hydroelectric Project, FERC License, and USACE Agreement

During construction of Warm Springs Dam, USACE conducted studies evaluating the feasibility of installing a hydroelectric plant. When the project was completed, it included minimum provisions for the future installation of a turbine. On July 27, 1983 SCWA filed an application to FERC for a major license under Part 1 of the Federal Power Act to construct, operate, and maintain Warm Springs Dam Hydroelectric Project Number 3351.

FERC issued SCWA a license to operate the facility on December 18, 1984. USACE issued a license to SCWA on December 18, 1984 for the use of land and facilities incidental to the construction and operation of the hydroelectric project effective April 1, 1985. Construction of the hydroelectric plant was completed in December 1988 at a cost of $5 million. The plant has a total generation capacity of 2.6 MW through a single turbine and generator unit.

SCWA entered into an agreement with USACE on December 22, 1989 providing for SCWA to operate and maintain the hydroelectric project. On January 4, 1989, SCWA entered into an agreement with PG&E, clarifying and standardizing the operating procedures for the project. An amendment to the power purchase agreement between SCWA and PG&E was entered into on January 31, 1989, which fixed the delivery capacity at 1.246 MW. The terms of the FERC license and the USACE agreement dictate project operations.

The FERC license contains a specific flow release schedule for Warm Springs Dam. The minimum flow releases from Warm Springs Dam required by FERC are met or exceeded as part of water supply operations conducted by SCWA or releases made to satisfy Decision 1610 (D1610). D1610 requires higher minimum instream flow from December 1 through March 31. Water supply releases during April through September generally exceed the FERC minimum instream flow requirements.

Each year between 11 and 15 million kilowatt-hours of power are produced and sold by SCWA to PG&E. In addition, SCWA also receives a “capacity payment” for the value of the power generation made available during the peak power demand season. To receive capacity payments, SCWA must generate a constant minimum of 1.246 MW during June, July, and August, which are the peak demand months for power consumption (PG&E 1984). Some short-term exceptions to this power requirement are allowed for circumstances that are beyond SCWA’s control. This contract expires in December 2008.

Dry Creek Channel Maintenance

Erosion control projects on Dry Creek were constructed by USACE in conjunction with the WSDP (USACE 1991). These projects were installed at 15 different locations along Dry Creek. They were constructed under three different contracts between 1981 and 1989. Project components include: grouted riprap sills, rock riprap bank stabilization, installation of steel piles with timber planking, derrick stone toe protection, grade control structures, concrete weirs, and a stilling basin. As in the case of the flood control works constructed by USACE on the Russian River, SCWA is responsible for the maintenance and operation of the works on Dry Creek and maintains these facilities following specifications identified in the WSDP O&M manual (USACE 1991).

Operation of Don Clausen Fish Hatchery

The design and construction of the DCFH was an original component of the WSDP. The proposed design of the hatchery at Warm Springs Dam was a part of the USACE Design Memorandum No. 12 Fish and Wildlife Facilities, dated December 1972 (USACE 1972).

Following recommendations by USFWS and CDFG, hatchery operations were revised by Supplement No. 1 to Design Memorandum No. 12 in December 1974 (USACE 1974). Supplement No. 1 dictates the release of minimum flows to support adequate spawning and rearing habitat in Dry Creek. Between April 1 and November 30, the minimum flow is 25 cubic feet per second (cfs). For the remainder of the year, flows were not to be less than 75 cfs, depending on downstream riparian diversions and storage levels in the reservoir. Minimum flow rates for Dry Creek were increased in 1986 by SWRCB D1610. D1610 is summarized in Section 1.4.3, and the resultant flow management is discussed in Section 2.1.4.

As described earlier in Section 1.4.2.1, the Water Resources Act of 1974 initiated USACE construction of fish facilities at Warm Springs Dam and Coyote Valley Dam. Additional fish production capabilities were included in the hatchery program goals to enhance harvest opportunities for Chinook salmon and coho salmon (USFWS 1978).

DCFH went into service on October 1, 1980 under the control of CDFG in accordance with an USACE and CDFG Agreement dated June 8, 1979 and amended May 1, 1982. This agreement was subsequently modified to provide additional compensation for losses to fish spawning and rearing habitat above both Warm Springs Dam and Coyote Valley Dam. DCFH was expanded and linked with CVFF. Both the DCFH expansion and CVFF became operational in 1992.

1.4.3 Water Rights and SWRCB Decision 1610

The SWRCB has statutory authority over appropriative water rights in California. Appropriative water-right permits and licenses specify maximum rates and quantities of direct diversion, diversion to storage, and rediversion. Direct diversion refers to water diverted from a stream for use within the same season. Diversion to storage refers to water diverted from a stream during one season, which then is held in storage for subsequent use during another season. Rediversion refers to water that first is diverted to storage, and then later is released back into a stream and diverted again (rediverted) for beneficial use at a point downstream.

Riparian water rights are derived from ownership of land that borders a stream or lake. Riparian owners may directly divert natural flow for beneficial purposes on riparian lands without an appropriative water-right permit. If the diverted water is to be stored for use in another season or on nonriparian lands, then an appropriative water-right permit must be obtained. In general, riparian users must share available supplies among themselves. Riparian rights normally remain with the riparian land when the lands are sold.

SCWA holds water-right Permit 12947A for storage of water at Lake Mendocino and for direct diversion and rediversion of water originating in the East Fork Russian River at SCWA's Wohler/Mirabel diversion facilities. Under this permit, the combined direct diversion and rediversion rates are limited to 92 cfs (average monthly rate) and 37,544 AF per year (AFY). SCWA holds water-right Permit 16596 for storage of water at Lake Sonoma and for direct diversion and rediversion of 180 cfs from the Russian River at Wohler/Mirabel. SCWA also holds water-right Permits 12949 and 12950 for direct diversions of 20 cfs and 60 cfs, respectively, at Wohler/Mirabel. The combined direct diversion and rediversion rates at Wohler/Mirabel under all four of SCWA's water-right permits presently are limited to no more than 180 cfs (116.3 million gallons per day [mgd]) and 75,000 AF during each October 1 to September 30 period.

SCWA controls and coordinates water supply releases from the Coyote Valley Dam and Warm Springs Dam projects in accordance with the provisions of D1610, adopted on April 17, 1986 (see Section 2.5). On March 8, 1985, SCWA and CDFG entered into an agreement specifying the minimum flows necessary for in-stream beneficial uses in both Dry Creek and the Russian River. D1610 incorporated the minimum streamflows contained in the agreement, which specifies a required minimum flow of 25 cfs in the East Fork Russian River from Coyote Valley Dam to the confluence with the Russian River. From that junction to Dry Creek, the minimum Russian River flows specified in D1610 are 185 cfs from April through August and 150 cfs from September through March during *normal* conditions, with reductions to 75 cfs and 25 cfs allowed during *dry* and *critically dry* hydrologic conditions, respectively. From Dry Creek to the Pacific Ocean, the minimum flow specified in D1610 is 125 cfs during *normal* conditions with reductions to 85 cfs and 35 cfs during *dry* and *critically dry* conditions, respectively. In Dry Creek, the minimum flows specified in D1610 are 75 cfs from January through April, 80 cfs from May through October, and 105 cfs in November and December during *normal* conditions. During *dry* and *critically dry* conditions, these requirements are reduced to 25 cfs from April through October, and 75 cfs from November through March.

SCWA has filed with the SWRCB an application for a new appropriative water-right permit and several petitions to change SCWA's existing water-right permits. The following sections summarize this application and these petitions.

1.4.3.1 Petitions to Add Points of Diversions for Russian River Customers

On June 10, 1991, SCWA filed petitions with the SWRCB to add three wells owned by the Windsor Water District (a predecessor to the Town of Windsor, which was incorporated in 1992), as additional authorized points of diversion and rediversion in SCWA's water-right Permits 12947A, 12949, 12950, and 16596. These petitions were filed to implement an agreement that SCWA entered into with the Windsor Water District on January 8, 1991. On January 4, 1994, the SWRCB issued an order granting these petitions.

On March 14, 1991, SCWA entered into an agreement with the Russian River County Water District (RRCWD) for the sale of water. On January 7, 1992, SCWA filed petitions with the SWRCB to add two wells owned by the RRCWD as authorized points of diversion and rediversion in SCWA's water-right permits. On May 10, 1994, the SWRCB issued an order granting these petitions.

The purpose of both of these sets of petitions (for Windsor and RRCWD) was to authorize water diversions and use by both districts under SCWA's water-right permits during times when no water is available in the Russian River for diversion under the districts' own water rights. This can occur during drier periods, when water in the

Russian River that has been released from storage in Lake Mendocino or Lake Sonoma is necessary to supply these diversions.

SCWA entered into similar agreements with the City of Healdsburg on November 17, 1992, and the Camp Meeker Recreation and Parks District on July 9, 1996. SCWA filed petitions with SWRCB on May 20, 1998, to add additional authorized points of diversion and rediversion for these entities' wells to the SCWA's appropriative water-right permits. SCWA also entered into an agreement with Occidental Community Services District on April 23, 2002, and filed a petition with the SWRCB on October 14, 2002 for this agreement. These entities will be authorized to divert water under these agreements if SWRCB issues orders granting SCWA's petitions for these agreements.

1.4.3.2 Petitions to Add Points of Diversion for New SCWA Facilities

SCWA filed petitions with the SWRCB on November 18, 1994 to add seven new points of diversion and rediversion to SCWA's water-right Permits 12947A, 12949, 12950, and 16596. The new points of diversion and rediversion consist of seven new water production wells, which were constructed in 1995 as the Russian River Well Field Development Project.

SCWA filed petitions with the SWRCB on March 17, 1999 to add Collector No. 6 (currently under construction), which is located in SCWA's Wohler diversion area, as a new authorized point of diversion and rediversion in Permits 12947A, 12949, 12950, and 16596.

On October 7, 1999, SCWA filed Application 30981 with the SWRCB for a new appropriative water-right permit for the direct diversion of 72 cfs of Russian River water at SCWA's existing intakes at Wohler and Mirabel and a new Collector (No. 6), currently under construction. The purpose of this application is to appropriate additional water for SCWA's WSTSP during times when there is surplus water in the Russian River. In its application and related petitions to amend SCWA's existing water-right permits, SCWA requested a combined limit for diversion and rediversion of 101,000 AFY at a maximum rate of 252 cfs under Permits 12947A, 12949, 12950, and 16596, and the new permit. On July 14, 2000 the SWRCB published notices of SCWA's petitions that were filed on May 20, 1998, March 17, 1999, and October 7, 1999.

1.4.3.3 Water Rights in Upper Russian River (Mendocino County)

Mendocino County's Ukiah and Hopland valleys, which extend from the confluence of West and East forks of the Russian River below Coyote Valley Dam to the Mendocino County line, generally comprise the service area of the MCRRFCD. The MCRRFCD holds water-right Permit 12947B, which authorizes the diversion and consumptive use of 8,000 AFY of Lake Mendocino and Russian River water. The SWRCB issued this permit in 1975, as a consequence of MCRRFCD's 1956 reimbursement to SCWA of part of the local cost of the CVDP.

Many water purveyors and individual water users divert water from the Russian River in Mendocino County. Some of the diversions are accounted for as being diversions of “natural flow” water (water that would be in the river without Lake Mendocino or any PVP imports) or diversion of water released into the watershed from the PVP. The remaining diversions are accounted for as rediversion of “project water” that is released from storage in Lake Mendocino.

MCRRFCD has no facilities to divert water from the Russian River. Instead, many water users divert “natural flow” or PVP water, or redivert “project water” released from storage in Lake Mendocino, under the MCRRFCD’s water right.

MCRRFCD reports direct diversions and rediversions of CVDP water from the Russian River mainstem by numerous individuals under MCRRFCD’s water-right permit. MCRRFCD estimates the quantities of natural flow and PVP water that are available and diverted, and accounts for those amounts of water as being diverted by water users with pre-1949 appropriative rights. If there is inadequate natural flow and PVP water available for all diversions by holders of pre-1949 appropriative rights, then MCRRFCD reports the remaining diversions by these water-right holders as being rediversions of project water under MCRRFCD’s water-right permit. The precise quantity of water actually diverted under valid pre-1949 appropriative rights is uncertain because this quantity varies with the crop types cultivated on the recognized pre-1949 places of use. The quantity of water diverted in Mendocino County prior to 1949 has been estimated to be 8,100 AF annually.

1.4.3.4 Water Rights in Lower Russian River (Sonoma County)

In addition to the rights for Coyote Valley Dam/Lake Mendocino water held by SCWA and MCRRFCD under Permits 12947A and 12947B, respectively, 10,000 AFY of CVDP water is reserved for rediversion for domestic and agricultural uses in Sonoma County. Water from this reservation is diverted and reported to the SWRCB by the individual water-right holders in Sonoma County. As in Mendocino County, many diverters in Sonoma County also hold pre-1949 appropriative rights, which authorize the direct diversion of available “natural flow” water and PVP water.

Municipal diverters of Russian River water in Sonoma County, other than SCWA, include the cities of Cloverdale and Healdsburg, the Town of Windsor, Geyserville Water Works, the RRCWD near Forestville, the Sweetwater Springs Water District in Guerneville and Monte Rio, the Camp Meeker Recreation and Parks District, and Occidental Community Services District. Some of these municipalities divert under SCWA water rights.

1.4.4 Russian River Estuary Management Responsibilities

A barrier beach (sandbar) forms periodically, primarily in the summer and fall, across the mouth of the Russian River, closing the Estuary and forming a lagoon. Historically, Sonoma County Department of Public Works breached the sandbar at the mouth when it closed to avoid flooding and property damage to adjacent lands (primarily in the Town of Jenner).

In 1992, the County of Sonoma, with assistance from the California State Coastal Conservancy, formed the Russian River Estuary Interagency Task Force (RREITF) to develop a management plan for the Estuary. The plan recommended a mechanical breaching program that reduced adverse environmental effects and protected private property from flooding. The management plan was adopted by the Sonoma County Board of Supervisors in 1995, and SCWA assumed responsibility for its implementation.

Since 1995, there have been, on average, five to seven mechanical breaching events per year. The sandbar has been breached using a bulldozer when water levels in the Estuary are between 4.5 and 7.0 feet in elevation. The goal is to manage water levels at the Jenner gage at or below 7.0 feet. This level was selected to avoid flooding in Jenner, minimize periods of poor water quality, and to avoid high flushing velocities following breaching. Water levels are determined from the automated tide recorder located at Jenner. The breaching schedule varies from year to year, depending on the frequency of closure of the Russian River mouth.

SCWA manages the breaching of the sandbar at the mouth of the Estuary in compliance with a number of state and federal permits and agreements. These include authorizations from California State Parks, the California State Lands Commission, the California Coastal Commission, CDFG, NCRWQCB, and USACE. Specifically, these permits and agreements include:

- California State Parks temporary use permit
- State Lands Commission General Lease for Public Agencies (PRC 7918.9)
- California Coastal Commission Coastal Development Permit (No. 2-01-033)
- CDFG 1601 Agreement (No. III-1176-96)
- SWRCB Waste Discharge Requirement (Order No. 81-73-WDR)
- USACE Clean Water Act Section 404 Permit (File No. 221211N)

1.4.5 SCWA River Monitoring Stations

The River Monitoring Stations Project was initiated in 1991 in response to requirements set forth by the California Department of Health Services (CDHS) as part of SCWA's domestic water supply permit (System No. 4910020, Water Permit No. 02-91-017). The project is intended to continuously monitor Russian River water to detect contamination prior to potential delivery to SCWA customers. The project includes collecting data on DO, pH, temperature, turbidity, depth, and conductivity simultaneously from five river monitoring stations between Hopland and Guerneville.

1.4.6 SCWA Flood Forecasting

On September 30, 1986, the Sonoma County Board of Supervisors and SCWA Board of Directors adopted Resolution No. 86-2070A approving development of a Flood Hazard

Mitigation Plan for Sonoma County. Section III of this plan requires SCWA to monitor changes in the Russian River floodway elevations and to alert the county's Director of Emergency Services when predetermined water levels are reached at various locations. Flood forecasting is done by SCWA in collaboration with the California Department of Water Resources (CDWR) using data from CDWR's River Forecasting Center. Flood forecasting predicts flood-crest levels in the lower Russian River so that evacuation plans can be made and steps taken to minimize property damage. Section IV of the plan requires SCWA to construct flood-hazard mitigation projects on a continuous basis. SCWA has agreements with the U.S. Geological Survey (USGS) and the California Department of Water Resources. These 1992 agreements are to maintain various stream-gaging stations on the Russian River (USGS 1992) and have access to information systems (USGS 1987) that provide stream-gage height and discharge information. This information is necessary for flood forecasting activities as well as managing flow releases to maintain water supply.

1.4.7 SCWA Zones 1A and 5A Flood Control Maintenance Responsibilities

In 1958, under the authority of SCWA's enacting legislation, the formation of nine geographical zones, each encompassing a number of hydrologic subareas in the watershed, was proposed as a means to finance, construct, and maintain flood control works in Sonoma County. Over the next several years, six of the nine flood control zones were formed, including two in the Russian River basin (Zones 1A and 5A). Zone 1A encompasses the Mark West Creek, Santa Rosa Creek, and Laguna de Santa Rosa subareas, which includes the cities of Santa Rosa, Sebastopol, and Windsor. Zone 5A encompasses the Russian River from the mouth to the Old Redwood Highway Bridge at Healdsburg, which includes the Austin Creek and Guerneville subareas.

The principal flood control facilities that SCWA maintains are located within Zone 1A in the Lower Russian River basin. Many of these flood control facilities were constructed as the Central Sonoma Watershed Project by SCWA under an agreement with the Santa Rosa Soil Conservation District and the U.S. Department of Agriculture, Soil Conservation Service ([USSCS] now called the Natural Resources Conservation Service). This project was approved under the authority of the Watershed Protection and Flood Prevention Act (Public Law 566, 83rd Congress, 68 Stat. 666 as further amended). The work plan for this project was approved in 1958 (USSCS 1958), and the project was constructed over the next 25 years. An operation and maintenance agreement was approved on February 12, 1974 (USSCS 1974). The project included the construction of five floodwater-retarding structures and the straightening, shaping, and stabilization of portions of 13 waterways to protect urban areas from flooding. SCWA has additional flood control responsibilities in Zone 1A that are not associated with the Central Sonoma Watershed Project. These include responsibilities along various drainages in and adjacent to the cities of Windsor, Santa Rosa, Rohnert Park, Cotati, and Sebastopol.

Zone 5A encompassed the Russian River from the mouth to the Old Redwood Highway Bridge at Healdsburg. Zone 5A was formed principally to finance construction of local drainage projects within the Vacation Beach area, Forest Hills Subdivision, and Riverlands Subdivision areas. No major flood control works were ever financed in Zone

5A along the lower Russian River. Maintenance work along the lower Russian River consists primarily of periodically removing fallen trees that impede flows when requested by landowners.

SCWA's flood control policies are identified in a series of resolutions adopted by the SCWA Board of Directors. Resolution DR 10073 adopted in July 1964 established that SCWA would only accept responsibility for the maintenance of drainage facilities that satisfy SCWA's adopted standards and specifications, which include flood control design criteria.

These standards and specifications were formally adopted by Resolution DR 17860 in November 1966, and were revised by Resolution 42127 adopted in September 1983. In its operation and management of flood control works, SCWA adheres to numerous contractual agreements, state and federal regulations, the conditions established for each flood control zone as defined in the *Engineers Report for Creation of Benefit Zones* (dated November 26, 1958 and modified by the SCWA Board of Directors resolutions regarding engineering, operation, and maintenance policies), and the conditions defined in the *Agency Report on Benefit Assessments for Flood Control Purposes Within Zones 1A and 2A* (SCWA Maintenance Department 1987-2001).

Overall, SCWA has permissive drainage easements along more than 150 miles of natural waterways in Sonoma County, and has constructed flood control channels in both Flood Control Zones 1A and 5A. Work is done following SCWA standards and specifications as described above, as well as under conditions specified by CDFG (under the Streambed Alteration Agreement, Section 1601 of the Fish and Game Code), the NCRWQCB (under Section 401 of the Clean Water Act, or waste discharge requirements specified in the state Porter-Cologne Act), USACE (under Section 404 of the Clean Water Act), and other permits as may be required. Right-of-ways are either owned in fee or SCWA holds a drainage easement. To perform this work in natural channels, SCWA has individual agreements and access easements with more than 1,100 property owners throughout Sonoma County. These agreements and the flood control design criteria discussed above largely specify the kinds of channel maintenance activities that SCWA performs.

1.4.8 Agreement for Water Supply

On October 24, 1974, SCWA entered into an agreement with the cities of Cotati, Petaluma, Santa Rosa, Rohnert Park, and Sonoma, and the Forestville, North Marin, and Valley of the Moon water districts ("water contractors"). Since 1974, the agreement has been amended eleven times, most recently in 2001. The Eleventh Amended Agreement for Water Supply superseded the Tenth Amended Agreement for Water Supply and Construction of Russian River-Cotati Intertie Project and authorized the implementation of the WSTSP (SCWA 2001a).

The Eleventh Amended Agreement authorizes SCWA to:

1. Construct or acquire additions to the existing transmission system sufficient to meet increased delivery entitlements established by the agreement for the water

contractors and to make the deliveries authorized by the agreement to the Marin Municipal Water District (MMWD);

2. Construct additional Russian River water production facilities up to a total capacity of 168.9 mgd so that the total water production capacity available at all times is not less than the average daily delivery to the regular customers and MMWD (excluding surplus water and water in excess of entitlements) during the month of highest historical use plus 20 mgd;

3. Construct emergency wells with capacities to be determined by the Water Advisory Committee;

4. Construct additional storage facilities (up to a total capacity of 174.3 million gallons) to the extent necessary to maintain a quantity of water in storage equal to 1.5 times the average daily delivery to the regular customers except North Marin Water District during the month of highest historical use; and

5. Replace existing facilities and construct additional facilities, related buildings, and appurtenances as necessary to ensure the reliable and efficient operation of the transmission system and to ensure that the quality of the water delivered complies with all applicable state and federal water quality requirements.

The Eleventh Amended Agreement specifies annual water delivery limits for each water contractor, except the Forestville County Water District.

The additional facilities authorized by the Eleventh Amended Agreement include an aqueduct generally paralleling the Russian River-Cotati Intertie; an aqueduct generally paralleling the south part of the Petaluma Aqueduct from the Russian River-Cotati Intertie to Kastania Reservoir; an aqueduct generally paralleling the Sonoma Aqueduct; an aqueduct connecting the Kawana Springs and Ralphine reservoirs; transmission line pumping plants necessary to regulate flows to storage facilities; 55.5 million gallons of additional tank storage; 56.9 mgd of additional Russian River water production capacity; water-treatment facilities; and additional groundwater wells.

The Eleventh Amended Agreement remains in effect until June 30, 2036, or, if any revenue bonds are outstanding on June 30, 2036, until such date as all revenue bonds shall have been paid in full. The Eleventh Amended Agreement provides that SCWA shall enter into renewal agreements for periods not to exceed 40 years each with any or all of the water contractors requesting the same for water supplies within the delivery capabilities of SCWA's transmission system. This would be at a cost no greater than SCWA's operation and maintenance costs and unreimbursed capital costs allocated on a proportionate use basis.

The Eleventh Amended Agreement also requires the water contractors to implement or use their best efforts to secure the implementation of urban water conservation best management practices (BMPs) as established by the California Urban Water Conservation Council; or implement or use their best efforts to secure the implementation of alternative water conservation measures that secure at least the same level of water savings.

The water contractors and SCWA must also implement or use their best efforts to secure the implementation of any water conservation requirements that may be added as terms or conditions of SCWA's appropriative water-right permits or licenses, or with which SCWA must comply under any applicable regulation or law.

1.4.8.1 MMWD Agreements

On July 3, 1975 SCWA entered into an agreement with the MMWD, entitled the "Offpeak Water Supply Agreement." This agreement provided for the delivery of water to MMWD not to exceed the annual amount of 4,300 AF, using excess capacity in SCWA's transmission system available during the off-peak months of the year. The water was conveyed to MMWD's distribution system via the North Marin Aqueduct pursuant to a wheeling agreement between MMWD and North Marin Water District that was entered into on September 11, 1974. The Offpeak Water Supply Agreement was amended three times, first in 1984, second in 1988, and thirdly, in 1996, when SCWA entered into a Supplemental Water Supply Agreement with MMWD.

The Third Amended Offpeak Water Supply Agreement increased the total quantity of water subject to a "take or pay" requirement from 2,500 to 4,300 AFY. It extended SCWA's obligation to release water from storage for use by MMWD to include the full year rather than just during the off-peak period. It conformed the agreement to language in Amendment No. 9 to the Agreement for Water Supply and Construction of the Russian River-Cotati Intertie Project that required the Russian River Conservation Charge paid by MMWD be credited to SCWA's Russian River Projects Fund. It added a new Russian River Projects Charge to be paid by MMWD in lieu of Sonoma County property tax money (other than the Warm Springs Dam tax levy proceeds) that is applied by SCWA for maintaining the Russian River water supply.

On October 22, 1991, SCWA entered into another agreement with MMWD entitled the "Agreement for the Sale of Water." This agreement provided for the sale of up to 10,000 AFY of additional water from SCWA to MMWD with maximum delivery rates varying from 9 mgd during May through October to 15 mgd during December through March. This agreement was amended in 1996, when SCWA entered into the Supplemental Water Supply Agreement with MMWD. The amendments added provisions regarding the Russian River Conservation Charge and the Russian River Projects Charge, and provisions for MMWD to make payments to SCWA in return for certain rights to stored water in Lake Mendocino and Lake Sonoma.

1.4.9 Recovery Planning MOU

In 2001, USACE, NOAA Fisheries, CDFG, and the counties of Humboldt, Mendocino, Sonoma, Marin, San Mateo, Santa Cruz, and Monterey entered into an MOU that established a collaborative process for recovery planning in the North-Central California Coast recovery planning domain. That MOU set forth an approach for local jurisdictions to support the identification and implementation of recovery goals established by the Technical Recovery Team. Signatories have agreed to participate in the NOAA Fisheries recovery planning process, as described in *Recovery Planning for West Coast Salmon* dated October 1999, and the *Recovery Planning Guidelines* dated September 1992 (NOAA Fisheries 1992). Some of the actions included in this BA would support recovery efforts envisioned by this MOU.

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As described in Section 1, this Section 7 Consultation is being conducted under the guidance of the Executive Committee, established by the 1997 MOU. The Executive Committee has defined the environmental baseline as conditions that existed before the MOU was signed on December 31, 1997. NOAA Fisheries defines the environmental baseline in a Section 7 Consultation as:

> *…an analysis of the effects of past and ongoing human and natural factors leading to the current status of the species, its habitat (including designated critical habitat), and ecosystem, within the action area* (USFWS and NMFS 1998).

The environmental baseline provides the foundation for developing proposed changes in operations to benefit listed fish species in the Russian River watershed. Understanding existing conditions is crucial to evaluating the potential effects of the proposed project on listed salmonids.

This section describes the regional setting within the Russian River watershed. It describes the historical and existing environment within the watershed and the status of the listed species and their life-histories. USACE, SCWA, and MCRRFCD facilities and operations under environmental baseline conditions are described in Section 3.

Section 2.1 includes information on hydrology, dams, local land uses, historical channel dynamics, habitat, and water quality. Knowledge of the basin's hydrology is critical to understanding both historic and current conditions. The regional setting under baseline conditions includes a wide range of human activities, and ongoing changes in these activities can exacerbate the impacts of non-project activities on listed fish species.

Section 2.2 describes the biological resources in the watershed and physical habitat conditions. Information on the species distribution, abundance, and other factors necessary to their survival is included as background for the analyses to be presented in the BA. Results of biological monitoring conducted within the watershed, as well as genetic studies, are presented.

2.1 RUSSIAN RIVER WATERSHED

2.1.1 WATERSHED OVERVIEW

California's Russian River drains a watershed of nearly 1,500 square miles centered 60 miles northwest of San Francisco, and empties into the Pacific Ocean near Jenner (Figure 2-1). The watershed is bordered on the west by the Coast Range and on the east by the Mayacamas Mountains, with the Sonoma Mountains occurring in the southern part of the watershed. Geologically, the area is characterized by northwest-trending mountain ranges and intervening alluvial valleys. Hills and mountains comprise 85 percent of the basin, and valleys make up the remaining 15 percent. Unstable Franciscan lithology underlies most of the mountainous regions, and landslides are common. The Russian River flows southward from its headwaters through small valleys and past the cities of Ukiah, Hopland, and Healdsburg before turning west at Mirabel Park. Joining the river near that point are flows from Mark West Creek and Laguna de Santa Rosa, which drain much of the southern portion of the basin. From Mirabel to the Pacific Ocean, low mountains along both banks confine the river for 22 miles. Major tributaries of the Russian River include the East Fork, Big Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek/Laguna de Santa Rosa.

Lying within a region of Mediterranean climate, the watershed is divided into a fog-influenced coastal region and an interior region with hot, dry summers. The basin-wide mean annual precipitation is 41 inches, with a range of 22 to 80 inches (USACE 1982). The greatest precipitation occurs at high elevations and in coastal mountains near Cazadero, while the lowest precipitation falls in the southern Santa Rosa Plain (USACE 1982). Approximately 93 percent of the annual runoff occurs from November to April (USACE 1986a, 1986b) during Pacific frontal storms.

Upstream from the East Fork confluence, the mainstem Russian River is uncontrolled by dams and drains an area of 100 square miles to the north and northwest. The East Fork Russian River drains an area of 105 square miles to the northeast of the Forks, but is controlled by Coyote Valley Dam and Lake Mendocino less than 1 mile above the East Fork/mainstem confluence. The East Fork Russian River receives interbasin transfers of water from the Eel River via the PVP.

2.1.1.1 Potter Valley Project

The PVP diverts water from the Eel River watershed through a tunnel to a powerhouse in Potter Valley, where it produces hydropower, and then discharges the used water to the East Fork Russian River above Lake Mendocino. This discussion of the PVP is provided solely as background information for this BA. Neither USACE nor SCWA controls operation of the PVP.

The PVP is comprised of Scott Dam and Lake Pillsbury, Cape Horn Dam, a diversion tunnel from the Eel River to the Russian River, and the Potter Valley hydroelectric power plant. Since 1908, PVP water diversions from the Eel River have generated power, irrigated agricultural land in Potter Valley, and augmented summer flows in the Russian River. PG&E purchased the PVP in September 1929. The quantity of water that can be diverted to the Potter Valley power plant is affected by the releases required to maintain the fishery in the Eel River. Diversion quantity is also affected by an agreement with the U.S. Forest Service to maintain high reservoir levels in Lake Pillsbury until Labor Day of each year for recreational use. The Potter Valley diversion tunnel has a maximum capacity of 350 cfs. From 1922 to 1992, diversions from Lake Pillsbury to the East Fork Russian River watershed averaged 159,000 AFY.

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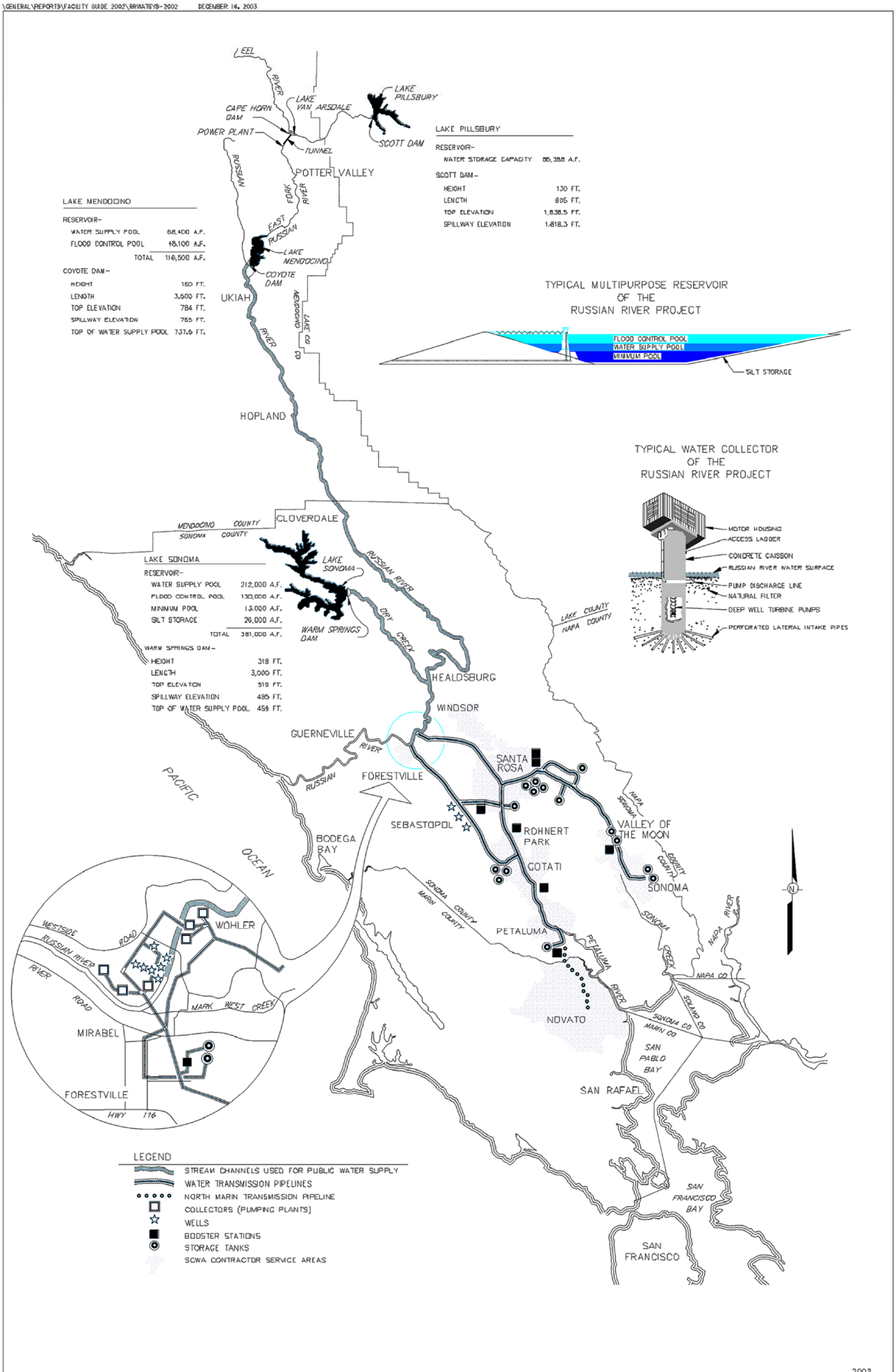

Figure 2-1 The Russian River Water System General Location Map

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Releases from Lake Pillsbury and the PVP are the subject of a separate Section 7 consultation between NOAA Fisheries and FERC (NMFS 2000a). Changes to the release criteria and minimum flow provisions in the 1983 FERC license for the PVP have been proposed and are the subject of an Environmental Impact Statement (EIS) issued in May 2000 by FERC. PG&E has already voluntarily reduced diversions so, if implemented, the proposed FERC license modification analyzed in the EIS would not substantially reduce the quantity of water currently diverted to the Russian River basin via the PVP.

The PVP diversion significantly altered the natural streamflow in the Russian River. Between construction of Scott Dam in 1922 and construction of Coyote Valley Dam in 1959, Eel River water stored in Lake Pillsbury and diverted to the East Fork Russian River helped provide significant base flows throughout the year. Presently, operation of the PVP is not coordinated with the operation of Coyote Valley Dam and is not subject to USACE, SCWA, or MCRRFCD control.

2.1.1.2 Coyote Valley Dam and Lake Mendocino

Lake Mendocino is impounded by Coyote Valley Dam on the East Fork Russian River, approximately 0.8-mile upstream of the confluence with the Russian River. Lake Mendocino is owned and operated by the USACE, San Francisco District, while the USACE Sacramento District's Water Management Division provides complete engineering support for the San Francisco District water management program. Information on the authorizing legislation is provided in Section 1.4.2.

The Coyote Valley Dam project is a multipurpose project providing a high degree of flood protection to areas below Coyote Valley Dam and supplying water for domestic, industrial, and agricultural uses. Releases from Coyote Valley Dam maintain flow in the Russian River during the summer months when the river would otherwise be dry, or nearly dry. Water releases from Coyote Valley Dam are designed to supply an adequate flow of water to the Russian River during the summer months to supply water needs and satisfy instream flow requirements. Winter operations include water storage until the dedicated flood storage space is reached and releases are made for flood control. Coyote Valley Dam and Lake Mendocino facilities and operation are described in detail in Section 3.

2.1.1.3 Warm Springs Dam and Lake Sonoma

Lake Sonoma is impounded by Warm Springs Dam at the confluence of Warm Springs Creek and Dry Creek, approximately 10 miles northwest of the city of Healdsburg. Lake Sonoma became fully operational in 1984. It is a multipurpose facility owned and operated by USACE for the primary purposes of flood control, water conservation, and recreation. Warm Springs Dam and Lake Sonoma facilities and operations are described in detail in Section 3.

2.1.1.4 Inflatable Dam

SCWA's inflatable dam and diversion facilities are located on the Russian River just upstream of the Mirabel area at River Mile (RM) 22. (The "RM" designation refers to the distance from the mouth of the river at the Estuary, upstream to the site referenced.) The inflatable dam is a key component of SCWA's diversion facilities. It consists of a rubber bladder attached to a permanent concrete foundation. The bladder is filled with water and, when fully inflated, the dam is 11 feet tall. The backwater impounded by the dam raises upstream water levels to improve infiltration and facilitate diversion operations. Fish ladders are located on both banks to provide fish passage. Additional details of the inflatable dam facilities and operation are presented in Section 3.3.

2.1.1.5 Fish Barriers

Natural Barriers

Obstacles including shallow water, cascades and falls, log jams, and other natural barriers limit upstream migration of adult salmonids into the upper reaches of tributaries. Locations of some barriers have been documented (CDFG 2002). CDFG reports natural barriers are found in Smith, Freezeout, Matanzas, Thompson, Briggs, Ingalls, Dutcher and Forsythe creeks.

Permanent Dams

Willow County Water Diversion Dam, owned by the Willow County Water District, is located at RM 88 in Ukiah. This permanent dam may affect fish passage into the uppermost reaches of the Russian River, where the best steelhead spawning and rearing habitat of the river is located (CDFG 1991). The dam is constructed of rocks and slabs of old concrete sidewalks, and is used for diverting water for irrigation (Winzler and Kelly 1978).

Seasonal Dams

Seasonal dams are temporary structures placed across the Russian River mainstem and its tributaries to impound water. The main purpose of these dams is to form pools for recreational use, although some also supply water (Winzler and Kelly 1978). These dams range from large structures that span parts of the Russian River mainstem to smaller structures located in the tributaries.

Three major seasonal dams are routinely installed in the mainstem Russian River during the summer recreation season. The major summer dams, starting from the downstream end of the Russian River and moving upstream, are Vacation Beach Dam, Johnson's Beach Dam, and Healdsburg War Memorial Beach Dam. A fourth dam, Del Rio Woods Dam, operated by the Del Rio Woods Recreation and Park District at RM 35, has not been installed since 2001.

Historically, these dams have been installed by the end of May and removed by mid-September so they do not impede the upstream migration of salmon and steelhead spawners. A very small number of Chinook salmon may begin their upstream spawning migration as early as late August. The risk of delay to Chinook salmon spawners, however, is extremely low because most upstream immigration occurs from late October to mid-January (Chase et al. 2001, 2002).

Because the outmigration of salmonid smolts primarily occurs during the winter-spring period and is usually completed by mid-May, the likelihood of outmigration delays due to the erection of the summer dams is low. The small number of Chinook salmon juveniles observed to emigrate between mid-May and June 30 would be delayed at the seasonal dams. However, these delays are likely short as there is generally sufficient flow to allow fish to pass over the tops of the dams.

The major seasonal dams are described below:

- Vacation Beach Dam is located at RM 12. The Russian River Parks and Recreation District operates the dam for recreation. It has a permanent 8-foot-tall concrete base with collapsible steel support beams. Wooden flashboards are installed during the summer to impound water. The dam includes a portable Denil fish ladder to permit fish passage when the flashboards are in place (CDFG 2002).

- Johnson's Beach Dam is located at RM 14 in Guerneville. It is also operated by the Russian River Parks and Recreation District for recreation. It is an 8-foot-tall permanent concrete and steel pier structure, with removable flashboards that are installed around mid-May. The dam also contains a fishway, which is constructed into the face of the dam, and is positioned to function best when water backs up due to the downstream Vacation Beach Dam. Future plans are to change the installation date to after June 15 to ensure there is no effect on the outmigration of salmonids and other fish species such as American shad (CDFG 2002).

- Healdsburg War Memorial Beach Dam is located at RM 32. The Sonoma County Regional Parks Department installs the dam for recreation. It is a 16.5-foot-tall concrete sill structure with removable flashboards and steel support beams. The date of flashboard installation varies from about May 20 to June 26, after most salmonids have finished migrating upstream.

  For Healdsburg Dam, a separate Section 7 consultation between USACE, SCWA, and NOAA Fisheries was conducted in 2000 to address construction and operation of a fish ladder at the dam. The ladder provides upstream passage for American shad and enhances passage conditions for salmonids when the flashboards are down (ENTRIX, Inc. 2000c). SCWA is the principal party responsible for the operation and maintenance of the fish ladder. The new ladder was constructed and began operating in 2002.

Several hundred summer dams are installed annually in tributaries throughout the Russian River (CDFG 2002). Most of these dams are located on private property and are typically used to create pools for recreational activities. The effects of these dams on listed salmonid species may include changes to stream-habitat complexity, diminishing stream water quality, enhancing habitat for salmonid predators, and restricting fish movement (NMFS 2001d). On smaller tributaries, however, Smith (2001, 2002) argues that if food is abundant in the impoundment, summer dams may actually provide improved habitat for steelhead rearing by creating smaller pools in shaded, back-country creeks. These cool pools could provide juveniles with a refuge to grow in before heading out to sea and a safe haven from predators.

Privately-owned summer dams are located primarily on small tributaries that are potential coho salmon and steelhead habitat. These dams can have substantial impacts on rearing and migration of salmon and steelhead, depending on their location, size, and time of deployment. CDFG and NOAA Fisheries have identified these dams as potentially impacting salmonid resources, and have identified specific actions that should be taken to minimize or eliminate these impacts (NMFS 2001d; CDFG 2002).

NOAA Fisheries (NMFS 2001d) prescribes timing of dam installation, conditions surrounding installation and removal, and the various applicable regulatory requirements. Strict enforcement of CDFG Section 1600 permits has recently been intensified in the Russian River as part of the state's efforts to protect and recover coho salmon. While these permits are required for any structure that could alter the structure of the streambed, in 1999 CDFG modified a Section 1600 program to comply with CEQA requirements (CDFG 1999). Currently, all persons who propose to construct a seasonal dam are required to notify the CDFG and to develop an agreement that will protect and/or mitigate any damages to the stream. The CDFG is using the Section 1600 permitting process to ensure that private owners of seasonal dams provide adequate bypass flows for listed salmonids.

NOAA Fisheries (2001d) has identified several effects of summer dams on salmon and steelhead beyond fish passage concerns. For instance, the installation and removal of summer dams near spawning sites can leave developing embryos vulnerable to crushing, cause the silting of redds, and lead to a reduction of DO to developing eggs. The installation of summer dams can also reduce the production of juvenile salmonids by reducing habitat complexity and damaging riparian vegetation. The dam installations can also change the availability of prey food by altering the volume of benthic drift in downstream reaches. Other potential adverse effects associated with summer dams include raising stream temperatures and enhancing the suitability of tributaries for prey species that feed on juvenile salmonids.

Both CDFG and NOAA Fisheries strongly support a shift from seasonal dams to off-stream reservoirs to eliminate much of the fish passage and other dam-associated effects on salmonids and their habitats. The intensified focus of fisheries agencies on the problems associated with seasonal dams and the commitment to intensify enforcement of laws regulating these dams should establish a trend toward eliminating their impacts on salmonid populations throughout the watershed (NMFS 2001d; CDFG 2002).

Road Crossings

Five temporary gravel road crossings on the Russian River and additional crossings on the tributaries provide cross-river access during the dry season. These five crossings are:

- Russian River at Washington School Road in Asti.
- Russian River at Odd Fellows Road near Korbel Champagne Cellars.

- Russian River at Summer Crossing Road in Guernewood Park.
- Russian River at Vacation Beach Avenue at Vacation Beach.
- Dry Creek/Russian River confluence crossing installed by Syar Industries each year.

A semipermanent crossing is installed on Dry Creek near its confluence with the Russian River. In addition to the above crossings, numerous other temporary crossings are installed in the Russian River by gravel mining companies. Two temporary crossings are installed by Shamrock Materials, Inc. near the confluence of Big Sulphur Creek and the Russian River. The exact locations of the gravel mining crossings vary from year to year, depending on the morphology of the Russian River and gravel operation needs. NOAA Fisheries has issued BOs for three gravel operations concerning the construction of summer road crossings and access to gravel mining sites (NMFS 2001a, 2002; NOAA Fisheries 2003c). The crossings have bridges or culverts to allow for streamflow. CDFG biologists report that summer road crossings have little or no effect on fish passage (CDFG 1991), but they may reduce the quality of fish habitat by increasing turbidity and covering aquatic invertebrates (Hopkirk and Northen 1980).

Culverts and Rural Road Crossings

A basin-wide assessment of all Sonoma and Mendocino county-owned culverts was conducted under contract to CDFG in 2001 and 2002 (CDFG 2002). Study protocols were consistent with recent NOAA Fisheries guidelines for salmonid passage at stream crossings (NMFS 2000a). Paved roads run parallel to large tributaries in all reaches of the basin, and numerous small dirt and paved roads in smaller canyons have thousands of culverts or fords at crossings. CDFG will coordinate initial restoration efforts on sites that have the best biological benefit for federal- and state-listed populations of anadromous salmonids (CDFG 2002).

Temperature and Chemical Barriers

Thermal barriers can be caused when low flows, lack of riparian vegetation, impaired hydrologic regimes, or point-source discharges of warm water increase water temperatures above thermal limits of listed fish species. CDFG has identified temperature barriers in long sections of streams within the Big Sulphur Creek watershed, where natural geothermal activity occurs (CDFG 2002). CDFG has also identified temperature barriers in the Maacama Creek watershed (McDonnel Creek subwatershed), where limited riparian vegetation occurs on long stretches of stream. Water temperature within the Russian River is discussed further in Section 2.1.6.1.

Chemical barriers are usually caused by a point-source discharge that makes water quality unsuitable. Wastewater releases may cause migration barriers and/or increased straying (CDFG 2002). CDFG has recommended a number of restorative actions to identify, monitor, and correct potential water quality concerns (CDFG 2002).

2.1.2 LOCAL LAND USES

2.1.2.1 Urban Development

Historical Perspective

Development of the Russian River Valley began in the early 1800s. Cattle and horse ranching were the dominant land uses. As ranching practices increased, much of the lowland area in the watershed was converted from forest to grasslands, with most streams flowing through a narrow corridor of riparian habitat.

The California Gold Rush in 1849 triggered the development of new settlements along the Russian River due to demand for wood and agricultural products from the region. Eventually, land transportation of agricultural products replaced steamboat shipping, resulting in the construction of roads in Sonoma and Mendocino counties. The pace of urban development in Sonoma County accelerated in the late 1800s to support the agricultural industry, particularly wine grape vineyards (Sonoma County 2003a). In 1870, a railroad was established between Petaluma and Santa Rosa. By 1910, Highway 101 was built, becoming a four-lane highway in the 1950s and a major U.S. freeway by 1980 (SCWA 1998a).

Current Practices

Approximately 65 percent of the urban development within Sonoma County is concentrated in Cloverdale, Healdsburg, Santa Rosa, Sebastopol, Rohnert Park, Cotati, Sonoma, Petaluma, and Windsor. All but two of these cities (Sebastopol and Sonoma) are located on Highway 101, the major north-south route through the county. The Sonoma County population in 2000 was 464,800, with 34 percent living in unincorporated areas of the county.

Between 2000 and 2002, the population of Sonoma County grew by 2.1 percent to an estimated size of 468,386 residents by 2002 (USDA Economic Research Service [ERS] 2003). The largest city in the county, Santa Rosa, has added approximately 5,635 residents since 2000, bringing its total population size to an estimated 153,489 residents (California Department of Finance [CDOF] 2003). Sonoma County's projected population growth from 2000 to 2010 is 19.9 percent (Sonoma County Economic Development Board 2003).

Mendocino County is also experiencing population growth, but not at the rate of Sonoma County. The 2000 population was 86,265. Between 2000 and 2002, the population of Mendocino County grew by 1.1 percent to 87,240 residents (USDA ERS 2003). Mendocino County's projected population growth from 2000 to 2010 is approximately 18 percent (CDOF 2001). The county's population is centered in the Ukiah Valley, where the City of Ukiah (the county seat and largest city) is located. Sixty-eight percent of the population live in unincorporated areas of the county, while 18 percent reside in the greater Ukiah area (CDOF 2003).

Residential, industrial, and commercial properties occupy about 6 percent of the land within the Russian River Valley. Communities that border the Russian River mainstem include Ukiah, Hopland, Cloverdale, Asti, Geyserville, Healdsburg, Rio Nido, Guerneville, Monte Rio, Duncans Mills, and Jenner. Communities located on tributaries to the Russian River include Windsor, Larkfield/Wikiup, Santa Rosa, Rohnert Park, Cotati, Sebastopol, Occidental, Camp Meeker, Forestville, and Graton. Several transportation routes connect these communities. These include U.S. Highway 101, State Highways 1, 12, 20, 116, 128, and 175, as well as several county roads and bridges. The Northwestern Pacific Railroad generally parallels the Russian River from Healdsburg north to Calpella. It should be noted that in both Sonoma and Mendocino counties, many residents live outside the Russian River watershed.

Current and future development in the Russian River watershed is based on general plans approved by the incorporated communities, and on general and specific plans developed by Mendocino and Sonoma counties. To date, approximately 90 square miles of the 1,485-square-mile Russian River watershed have been developed for commercial, industrial, and residential needs, with the cities of Ukiah and Santa Rosa showing the fastest growth in light industry and commercial development.

Primary industrial activities in the watershed include production and processing of timber products, wine products, agricultural and animal products, gravel mining, and energy production. Recreation and tourism are also major industries in the watershed, including hiking, camping, canoeing, swimming, fishing, and visiting wineries (Sonoma County 1989; Mendocino County 1981).

Potential Effects on Salmonids

The California Department of Conservation (CDOC) issues maps designed to help local governments evaluate land-use-planning decisions (CDOC 2003). These maps were developed as part of CDOC's Division of Land Resource Protection, which map 44.5 million acres of California's public and private land every 2 years to provide spatial information on land use.

In Sonoma County, urbanization increased at a faster rate between 1998 and 2000 than in the previous 2 years, and a significant amount of land was reclassified from dryland agricultural uses to vineyards and other irrigated crops. Recent maps show that 4,626 net acres in Sonoma County were converted to urban development between 1998 and 2000, compared to only 2,111 acres between 1996 and 1998. There was also a net increase in farmland of 3,469 acres, continuing the trend from 1996 to 1998, in which the county gained 1,260 farmland acres. In general, the increase in urban and irrigated agriculture land has occurred in areas that were historically used for dryland grain and grazing purposes. The CDOC reports that Sonoma County has already committed 1,071 acres to non-agricultural uses, which most likely will be earmarked for development in the future (CDOC 2003).

A study by Harris et al. (2001) on the effects of land policies and management practices on salmon has found that several land-use activities in Sonoma County (and other counties) may pose a risk to anadromous fish. These activities include sediment loading due to improper stream crossings, road failures, bank instability, and other erosion-causing activities associated with development. Additionally, urbanization can degrade water quality through stormwater runoff and removal of riparian habitat. These activities can degrade salmonid spawning and rearing habitat.

2.1.2.2 Gravel Mining

Historical Perspective

Since the mid-1800s, small-scale gravel mining on the Russian River has occurred between Fitch Mountain in Healdsburg and the Wohler Bridge. Gravel mining activity increased in the late 1940s when demand for sand and gravel increased and the USACE began constructing flood control projects. In-channel gravel extraction soon became one of the principal industries for towns located between Healdsburg and Ukiah. Russian River gravels were used in concrete developments and road construction throughout the Russian River Valley and the San Francisco Bay Area (EIP Associates 1994).

In the 1970s, in-channel gravel mining decreased and operations moved to the adjacent terraces along the river. Between 1980 and 1995, approximately 42 million tons (a yearly average of 2.8 million tons) of gravel were removed by instream and terrace mining operations (EIP Associates 1994). In September 1994, the Aggregate Resources Management Plan (ARM) for Sonoma County was revised to address future demands for aggregate resources through 2010. It was anticipated in the ARM Plan that demand would range from 75 million tons to 175 million tons (EIP Associates 1994).

Current Practices

Three extraction methods are used in the Russian River basin: in-channel mining, terrace or pit mining, and quarry mining. In-channel methods remove material directly from stream channels. Gravel is skimmed from bars or excavated directly from active-channel deposits that emerge during low flows. Terrace or pit mining removes gravel from historic or active flood plain deposits. The pits are separated from the active channel by buffer zones of varying width. Some pits are deeper than the adjacent river channel elevation by as much as 44 feet (Steiner 1996). Quarry mining uses sites away from the stream and its floodplain, and uses as much as 20,000 gallons of water per day (gpd) for large operations (EIP Associates 1994).

Entrapment or stranding of fish in depressions associated with gravel mining in the active floodway of the Russian River is a concern. Aggregate and sediment removal operations can leave depressions in mined areas (bars) that can increase the potential for entrapment (NOAA Fisheries 2003b). Of the three extraction methods used in the Russian River, quarry mining has the least direct effect on salmonid habitat.

The ARM Plan, adopted by Sonoma County in 1980 and revised in 1994, established locations, policies, and standards for terrace and instream mining operations (EIP Associates 1994). The objective of the ARM Plan is to manage quarry production on a sustained-yield basis and provide guidelines to reduce bank erosion, maintain flood-flow capacities, protect adjacent land uses, and minimize effects on fisheries, vegetation, and wildlife. The ARM Plan allows instream mining of gravel bars at levels that balance the rate of aggradation and degradation.

In 1998, as part of the 1994 ARM Plan, SCWA assisted the Sonoma County Permit and Resources Management Department in monitoring riparian and aquatic habitat along the Russian River to assess effects of multiyear bar-skimming operations. Monitoring showed a prevalence of undeveloped riparian habitat along stream channels, such as immature forests and vegetative scrub, suggesting there has been an increase in flood scour and a decrease in the size of the active floodplain in recent years. While 52 percent of the existing riparian stands were established before or during 1947, most of the habitat loss on banks and terrace areas has resulted from development of the floodplain (especially since 1987).

One of the predominant issues in the ARM Plan program is to assess the effects of instream mining operations on anadromous fish habitat. To address the effects of mining on salmonids in the Russian River, NOAA Fisheries issued biological opinions (BO) for the mining companies including Syar Industries, Shamrock Materials, Inc., and DeWitt Sand and Gravel (NMFS 2001a, 2002; NOAA Fisheries 2003c, respectively). In their assessment of these mining operations, NOAA Fisheries proposed several conservation measures to minimize the adverse effects of gavel extraction on listed species. NOAA Fisheries also recently issued a BO for gravel mining and habitat enhancement in Austin Creek (NOAA Fisheries 2003d).

The Mendocino County Water Agency is also developing a gravel management plan for the Russian River in Mendocino County to reduce the effects of mining on listed salmonids. Instream mining takes place at four locations in Mendocino County (CDWR 1984). Three of these locations are on the mainstem Russian River below Ukiah, and one instream mining area is located in Redwood Valley on the West Fork Russian River (CDWR 1984).

Potential Effects on Salmonids

NOAA Fisheries (NMFS 2002) has identified several potential effects of gravel mining on Russian River salmonids. These effects include river incision, bank erosion, habitat complexity reduction, and tributary down-cutting (NMFS 2002). The 1994 ARM Plan also found that gravel mining reduces riparian vegetation along stream corridors and increases sediment deposition within streambeds. Finally, EIP Associates (1994) have reported that mining practices can alter flows, especially in high-velocity channels, leading to the removal of spawning gravels. All of these activities can negatively effect salmonids by reducing the amount of quality habitat available for spawning and rearing.

2.1.2.3 Timber Harvest

Historical Perspective

Logging has occurred in the Russian River watershed since the late 1800s. Intensive logging and milling began in 1865, following the construction of a power-driven sawmill in Mirabel Park, and production reached its peak in the mid-1900s (CDFG 2002). After most harvestable redwoods had been removed, loggers switched to Douglas fir during World War II. Since then, timber harvesting in the Russian River watershed has dramatically declined (CDFG 2002).

Current Practices

Since 1975, the California Department of Forestry (CDF) has required logging companies to comply with timber harvest plans (THPs) when harvesting more than 20 acres. Regulations for THPs are set forth in the Federal Forest Practice Act, which is administered by CDF and other state regulatory agencies. These regulations govern harvesting rates, erosion control, watercourse and lake protection, and hazard reduction (CDF 2003).

Currently, less than 5 percent of the timber harvested in California's northwest region comes from the Russian River watershed. Although logging has decreased since the mid-1950s, there are currently many active THPs within the Russian River watershed. While some of the THPs are located near tributaries in the more mountainous regions, most are located in the lower mainstem west of Guerneville, and the upper mainstem near Ukiah (SCWA 1998a).

Potential Effects on Salmonids

The main effect of timber harvesting on fish species in the Russian River is soil erosion (NCRWQCB 2003a). Soil erosion is caused by landslides that result from the destabilization of slopes due to the removal of trees. Timber-related landslides can affect listed salmonids by silting out spawning habitat, raising stream and river temperatures, and destabilizing streambanks (NCRWQCB 2003a).

2.1.2.4 Agriculture

Historical Perspective

By the second half of the 19th century, Mendocino and Sonoma counties had became two of the nation's biggest wine producers. Other crops grown in the region included prunes, apples, cherries, hops, olives, berries, potatoes, asparagus, melons, and other vegetables. The production of eggs, poultry, dairy products, beef, and lamb were also important economic farm commodities (California Farm Bureau Federation 2003). Most land currently in agricultural production has been grazed or cultivated for many years. Substantial areas of undeveloped lands that were not in agricultural production have been converted to vineyards in recent years (CDOC 2003).

Current Practices

Agricultural land in the Russian River watershed is mainly vineyards, and to a lesser extent, orchard crops. Major orchard crops are prunes, pears, and apples, but other crops such as cherries and walnuts are also grown. There is considerable grazing by cattle and sheep in some areas, but far less than in the past. The watershed contains both dry and irrigated pasture, and hay and grains are grown. Irrigation water is generally needed from May through early October. Water is used in the spring for protecting vineyards from frost (USACE 1998b).

In Sonoma County, wine grapes are currently grown on 59,891 acres. Sonoma County's total wine grape production for 2002 was 46,587 acres valued at $376 million (Sonoma County Agricultural Commission [SCAC] 2002). Mendocino County has approximately 15,000 acres of wine-bearing vineyards worth $81 million in 2002 (Mendocino County Agricultural Commission 2002b).

Historically, the demand for North Coast wine grapes far outstripped supply, but that has changed in recent years. Currently, vineyard development has tapered off as a result of a grape surplus in Sonoma and Mendocino counties (M. Vernon, SCAC, pers comm. 2003; G. McCourty, University of California Hopland Research and Extension Center [UC HREC], pers. comm. 2003). This surplus has resulted in lower profits for grape growers (SCAC 2003a).

Potential Effects on Salmonids

In the past few decades, Sonoma County vineyards have expanded to the hillsides, where erosion is a more significant problem than on flat ground. This has lead to additional sedimentation of the Russian River via runoff from hillside vineyards into streams and tributaries (NCRWQCB 2003b).

The NCRWQCB does not have a formal permitting process for vineyards. Recently, Sonoma County adopted a hillside vineyard ordinance to address sedimentation problems associated with vineyard operation. Sonoma County's Agricultural Commission oversees the Vineyard Erosion and Sedimentation Control Ordinance (VESCO), which requires growers to submit erosion control plans for new vineyards with a greater than 10 percent slope. The VESCO also addresses the effect of vineyard operations on riparian areas (SCAC 2003b). This is the first effort by the county to regulate vineyard development.

The 1981 Mendocino County General Plan acknowledges a link between salmonid populations and agricultural practices, but the details of this relationship were not well developed within the plan. The revised General Plan Update, due out in 2006, will evaluate the effects of agricultural activities on fish species in order to reduce negative impacts. Mendocino County recently developed a Draft Grading Ordinance (Mendocino County 2002), that is in the process of being adopted, to regulate grading on public and private lands in unincorporated areas to protect fish habitat.

2.1.2.5 Existing Water Quality Conditions

Water quality sampling programs conducted in the Russian River watershed over the last 20 years indicate substantial improvements in water quality throughout the watershed (NCRWQCB 2002a). Efforts to control both point-source pollution (i.e., discharges from municipal and industrial treatment plants) and nonpoint-source pollution (i.e., urban and agricultural runoff) are largely responsible for improvements in water quality.

Some water quality issues remain in locations near animal (primarily dairy) operations, cultivated agriculture, industrial sites, timber harvesting, and in locations downstream from urbanized areas. These issues include impacts on domestic water supplies and fisheries from stormwater runoff, chemical usage, and wastewater (NCRWQCB 2002a). The NCRWQCB has identified several areas of concern in the tributaries, including sedimentation, riparian vegetation removal, low streamflow, bacteria, channel maintenance practices, and high water temperatures.

Toxic Substance Detection

Toxic substances have rarely been detected in Russian River monitoring programs (NCRWQCB 2002a). Sediment sampling in 1985 to 1986 and again in 1995 detected no pesticides in sediments. Monitoring of heavy metals exhibited no trends, except for higher zinc concentrations downstream from the more urbanized areas. Toxic substance sampling in resident fishes and in transplanted (i.e., caged) freshwater clams as part of the NCRWQCB's Surface Water Ambient Monitoring Program has occasionally detected pesticides and/or heavy metals in tissues. However, the only consistent trend is the presence of mercury in fish from lakes Pillsbury, Mendocino, and Sonoma, detected as part of the Toxic Substances Monitoring Program (NCRWQCB 2002a).

ESA Compliance

The NCRWQCB entered into an agreement with SCWA to review water quality standards and regulations and SCWA activities in the watershed for compliance with the ESA (NCRWQCB 2002a). Water bodies in the Russian River/Bodega watershed management area were assessed in light of existing and proposed standards and permits, and opportunities to improve water quality and salmonid resources were identified (NCRWQCB 2000). The NCRWQCB staff report recommended modifying selected objectives in the Water Quality Control Plan for the North Coast Region (North Coast Basin Plan; NCRWQCB 2000). The recommended changes include adjusting existing standards for DO and temperature to protect critical salmonid lifestages, and adopting new standards for sedimentation, aluminum, and nutrients. The recommendations are currently being finalized by the NCRWQCB.

River Water Quality Monitoring Programs

Data on surface water quality within the Russian River watershed have been collected at over 50 monitoring stations by seven different agencies including the City of Santa Rosa, CDFG, CDWR, Mendocino County Water Agency, NCRWQCB, SCWA, and USGS (Figure 2-2). These stations are located along the mainstem Russian River and in selected

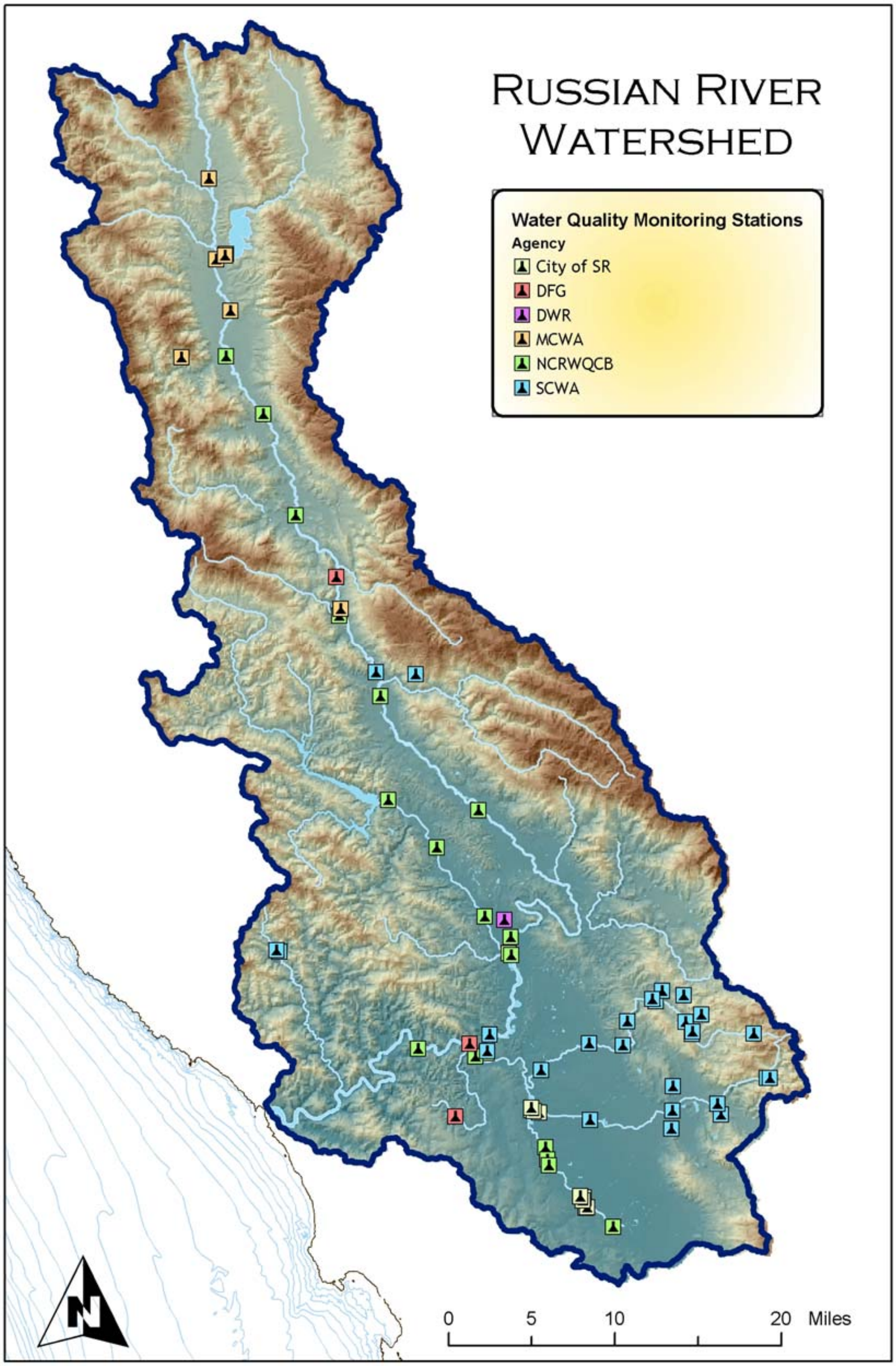

Figure 2-2 Locations of Water Quality Monitoring Stations in the Russian River Watershed. Source: SCWA

tributaries, particularly the Mark West Creek–Laguna de Santa Rosa system. Water quality parameters collected at these stations are variable and primarily include temperature, DO, pH, and specific conductivity. Other water quality parameters occasionally measured include turbidity, chemical oxygen demand, nutrients, metals, organic compounds (including pesticides), chlorophyll, and bacterial abundance. SCWA is currently compiling these data.

Reservoir Water Quality Monitoring Programs

USACE routinely conducts water quality monitoring of Lake Mendocino and Lake Sonoma during April and August of each year (Baum 2003a, 2003b). Samples are collected within the reservoirs and at the inflows and outfalls. Parameters monitored include Secchi disc depths (i.e., a measure of water clarity); water-column profiles for temperature, DO, and pH; phytoplankton; metals; methyl tertiary-butyl ether (MTBE); pesticides; inorganic parameters (i.e., alkalinity, nutrients); and fish-tissue mercury.

Both Lake Mendocino and Lake Sonoma are mesotrophic, which means they have moderate levels of nutrients and phytoplankton productivity (Baum 2003a, 2003b). During the spring, both lakes are thermally stratified. Lake Sonoma continues to exhibit temperature stratification in the summer, whereas Lake Mendocino tends to develop uniformly warmwater temperatures with depth, because releases from the dam are made from the coldwater pool at the bottom of the lake. DO concentrations remain relatively high with depth in Lake Sonoma. However, DO levels decrease with depth in Lake Mendocino (Baum 2003a).

Water quality in both Lake Mendocino and Lake Sonoma is generally good with only occasional exceedances of water quality criteria for the protection of aquatic life, as defined in the California Toxics Rule (CTR) (Baum 2003a, 2003b). Pesticides were not detected in either lake between 1997 and 2002.

In Lake Mendocino, dissolved mercury exceeded the aquatic life criterion in bottom waters in 1999 and 2000, and manganese slightly exceeded the aquatic life criterion in 2001. Mercury may also be elevated in fish tissue (Baum 2003a). MTBE was not detected in Lake Mendocino at concentrations exceeding the detection limit of 2 micrograms per liter (μg/l) (Baum 2003a).

In Lake Sonoma, some metals have exceeded the water quality criteria as defined in the CTR (Baum 2003b). These metals include: dissolved copper in the spring of 1995 and the summer of 1997; dissolved zinc in the summer of 1997; dissolved mercury in bottom waters in 1998, 1999, and 2000 (and possibly elevated in fish tissue based on limited sampling in 2000 and 2001); and MTBE at a concentration of 3 μg/l in the summers of 2000 and 2002 (Baum 2003b).

Total Maximum Daily Load Program

Under Section 303(d) of the federal CWA, states are required to develop lists of impaired waters that still do not meet water quality standards after all known point sources of pollution have been addressed. Section 303(d) requires that the states establish priority rankings for waters on the lists and develop Total Maximum Daily Loads (TMDLs) for these waters (EPA 2003a). TMDL lists are to be updated every 2 years.

A TMDL is a quantitative assessment of water quality problems and contributing pollutant sources (EPA 2000). A TMDL includes a calculation of the maximum amount of a pollutant that a water body can receive and still meet water quality standards. A TMDL allocates pollutant loadings among all sources and provides a basis for taking actions to achieve water quality standards (EPA 2000). The calculation must include a margin of safety and account for seasonal variation in water quality to ensure that the water body may be used for the purposes that the state has designated.

The Russian River watershed, particularly the tributaries, were included in the Section 303(d) list for impairment due to sedimentation and siltation in December 1997 (NCRWQCB 2001b). TMDLs for these water bodies were given a medium priority with a completion date of 2011. Upon completion of each TMDL, the waste-load allocations will be incorporated into the North Coast Basin Plan through the normal revision process.

The EPA recently approved California's 2002 revision to the Section 303(d) list. This listing added five water body segments in the Russian River to the 1998 list (Table 2-1). Five segments were also placed on the "watch list" for pesticides and metals (NCRWQCB 2001b). Water bodies are added to the watch list when there is either conflicting information on impairment, or there is insufficient data to make a decision. The NCRWQCB is responsible for collecting additional information about the water body segments on the watch list during the Table 2-1 listing cycle. These data will be used to make a determination as to whether to list the water body segment as impaired.

Additions in the 2002 Section 303(d) list include the Laguna de Santa Rosa for DO and nutrients, Santa Rosa Creek for pathogens, and the Russian River for pathogens and temperature. The rationale for these additions is provided in the following paragraphs.

The Laguna de Santa Rosa is seasonally eutrophic (i.e., it has high nutrient levels, high phytoplankton productivity, and low water clarity). The Laguna de Santa Rosa was added to the Section 303(d) list in 1990 due to high levels of ammonia and low DO concentration. A TMDL for ammonia and DO was completed in 1995, and implementation is underway to reduce and/or eliminate nutrient sources necessary to improve water quality as part of a waste reduction strategy. Ammonia goals were met ahead of schedule, but DO continues to be a problem due to nutrient-enriched bottom deposits in the Laguna de Santa Rosa. The Laguna de Santa Rosa was relisted for impairment due to low DO and nutrients in 2002.

Although the quantity of samples is low, microbiological monitoring in Santa Rosa Creek has identified high levels of bacterial indicators (NCRWQCB 2001b). Results from samples collected during June/July 2001 indicated that most samples exceeded one or more of the bacteriological criteria established by the CDHS. Monitoring results from June/July 2001 show high levels of total coliforms, *Escherichia coli (E. coli)*, and *Enterococcus* (City of Santa Rosa 2001, as cited in NCRWQCB 2001b). Total coliform

Table 2-1 Water Quality-Impaired Water Bodies in the Russian River Watershed

Water Bodies	Status	Parameter	Priority	Proposed TMDL Completion Date
Atascadero Creek	Listed	Sedimentation		2011
Green Valley Creek	Listed	Sedimentation		2011
Laguna de Santa Rosa	Listed[1]	DO	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
	Listed[1]	Nutrients		
	Watch[1]	Copper, Chromium, Zinc		
	Watch[1]	Diazinon		
Lake Mendocino	Watch[1]	Mercury	Low	
Lake Sonoma	Watch[1]	Mercury	Low	
Russian River	Watch[1]	Diazinon		
Russian River, Austin Creek Hydrologic Service Area (HSA)	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Big Sulfur Creek HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Coyote Valley HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Dry Creek HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Forsythe Creek HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Geyserville HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Guerneville HSA	Listed[1]	Pathogens[2]	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Mark West Creek, HAS	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Russian River, Ukiah HSA	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
Santa Rosa Creek	Listed[1]	Pathogens	Low	
	Listed	Sedimentation	Medium	2011
	Listed[1]	Temperature	Low	
	Watch[1]	Copper, Chromium, Zinc		
	Watch[1]	Diazinon		

[1] Added on the California 2002 Section 303(d) listing.
[2] Listing only covers the Monte Rio area between the confluences of Dutch Bill and Fife creeks, and the Healdsburg Memorial Beach from the Highway 101 crossing to the railroad crossing upstream of the beach.

and *E. coli* levels greater than CDHS-recommended levels were found in 72 percent of the 18 samples analyzed. All of the samples had *Enterococcus* levels exceeding the CDHS-recommended level. There were not enough data collected over a 30-day period to make a determination of water quality objective exceedance for contact recreation, based on the NCRWQCB's North Coast Basin Plan objective for fecal coliform (NCRWQCB 2001b). (Fecal coliforms are indicator organisms for other pathogens.) However, swimming advisories have been issued for Santa Rosa Creek (NCRWQCB 2002a). Healdsburg Memorial Beach and Monte Rio Beach are popular swimming areas on the Lower Russian River. The river in the vicinity of these beaches has regularly exceeded water quality objectives for fecal coliforms (NCRWQCB 2001b). Swimming advisories may be implemented to protect human health in these areas.

Permitted Wastewater Discharges

Approximately 176 facilities are regulated under National Pollutant Discharge Elimination System (NPDES) permits or Waste Discharge Requirements (WDR) by the SWRCB within the Russian River watershed. Most of these facilities are concentrated in the urbanized areas including Santa Rosa and Healdsburg (38 facilities each), Geyserville (17 facilities), Ukiah (16 facilities), and Cloverdale (12 facilities) (SWRCB 2003).

The North Coast Basin Plan adopted by NCRWQCB in 1993 established policy and an implementation schedule for controlling wastewater discharges to the Russian River. Exceptions are made on a case-by-case basis and are defined in the NPDES permit for each discharger. The SWRCB has issued 27 NPDES permits for activities that discharge to surface water. These activities include discharge of domestic and industrial sewage, nonhazardous wastes from dewatering activities (e.g., from CVFF), contaminated groundwater, nonhazardous manufacturing process wastes, and stormwater. Base flows (discharge from facility) and the number of permitted facilities for each of these classifications are provided in Table 2-2.

Table 2-2 Classification of NPDES-Permitted Facilities along the Russian River

Waste Type	Permitted Facilities	Base Flow (mgd)
From dewatering, recreational lake overflow, swimming pool, water ride, or groundwater seepage	6	0.03
Contaminated groundwater	8	0.21
Nonhazardous industrial process waste	3	0.52
Nonhazardous domestic and industrial sewage	9	22.1
Stormwater runoff	1	0.0001

The greatest contribution to flow is from the nine sewage treatment plants that discharge a base flow of 22.1 mgd to the Russian River or its tributaries during a limited portion of the year. These treatment plants are allowed (by NPDES permits) to discharge to surface waters from October 1 through May 14 at a maximum rate, for most treatment plants, of 1 percent of the flow of the receiving water (NCRWQCB 2002a). In addition, the municipal dischargers must meet, or be on a time schedule to meet, advanced waste treatment levels (i.e., tertiary treatment without full nutrient removal) (NCRWQCB 2002a).

The North Coast Basin Plan allows exceptions to the discharge rate provision as specified in individual NPDES permits. The City of Santa Rosa's sewage treatment plant has an exception, as specified in Resolution No. 89-111, that allows discharge rates as high as 5 percent of the flow rate of the Russian River during the discharge period (i.e., October 1 to May 14) when approved by the NCRWQCB's Executive Officer (NCRWQCB 2002a).

Several industrial wastewater discharges are allowed under provisions of NPDES permits that require compliance with applicable water quality standards. Likewise, discharges from the cleanup of contaminated groundwater and discharges from leaky underground petroleum storage tank sites are permitted in low volumes and at nondetectable contaminant levels. The City of Santa Rosa, Sonoma County, and SCWA are co-permittees under an NPDES municipal stormwater permit for stormwater point-source discharges in the Santa Rosa area.

Nonpoint-source discharges from failing septic systems and other sources along the Russian River have not been fully identified (SCWA 1998a).

Stormwater Runoff Sampling

Santa Rosa is the largest municipality within the Russian River watershed that is currently subject to an NPDES stormwater permit (NCRWQCB 2003c). Other smaller municipalities are being required to obtain NPDES permits under Phase II of the stormwater program. The SWRCB has issued a statewide stormwater NPDES permit to the California Department of Transportation to control stormwater discharge from state roadways.

Because SCWA has jurisdiction over flood control channels within the Santa Rosa area, SCWA has entered into an interagency agreement with the City of Santa Rosa and the County of Sonoma for coverage under NPDES Permit Number CA0025054 for stormwater discharges (see Section 4.4.6).

The three agencies—SCWA, City of Santa Rosa, and County of Sonoma—are responsible for managing activities that contribute to stormwater runoff and for conducting monitoring of stormwater during rainfall events. Each agency has different responsibilities in implementing the management and monitoring program (Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 2003). The County of Sonoma and SCWA are responsible for performing the chemical monitoring component of the program. This involves collection of water samples in Santa Rosa Creek upstream and downstream of the urban area of Santa Rosa during the "first flush" event (i.e., the first storm that produces 0.1 inch of rainfall and generates runoff at both upstream and downstream sampling locations) and three representative storm events (at least 0.3 inch of rainfall within a 3-hour period) throughout the rainy season. The City of Santa Rosa is responsible for performing biological monitoring during two storm events to assess the biological impact of urban runoff. The biological monitoring includes both benthic invertebrate surveys and bioassays.

During the first permit term (1997 to 2003), samples were analyzed for total suspended solids (TSS); total dissolved solids (TDS); pH; temperature; nitrite and nitrate nitrogen; total Kjeldahl nitrogen (TKN)[1]; total phosphates; dissolved phosphates; fecal coliform; fecal streptococcus; and the priority pollutants (a selection of 126 metals, volatile organic compounds [VOCs], and semivolatile organic compounds [SVOCs]) (Sonoma, County of, City of Santa Rosa, and SCWA 2003). The color, odor, turbidity, and presence of oil sheen and surface scum are described by the sampler on the chain-of-custody form at the time of sample collection.

Many of the chemical constituents for which analysis was conducted were never detected in the 17 rounds of sampling during the first permit term. These constituents, including VOCs and SVOCs, have been eliminated from the future sampling program because there is no reason to suspect that they will be detected in future sampling events (County of Sonoma, City of Santa Rosa, and SCWA 2003).

Additionally, the permittees propose to eliminate metals from future analysis under stormwater sampling (Sonoma, County of, City of Santa Rosa, and SCWA 2003). Of the 17 samples that were analyzed during the first permit term, there was only one detection of any of the metals above the CTR aquatic life criteria (i.e., mercury in October 1998). The detected concentration was just above the detection limit and considered suspect (Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 2003). Mercury was not detected in any of the 11 samples collected after this detection.

2.1.3 Hydrology

Surface water hydrology in the Russian River basin strongly reflects the area's Mediterranean climate: warm, dry summers and cool, wet winters. Greater than 82 percent of the precipitation falls during the months of November through March (Western Regional Climate Center 2003). Snowfall is uncommon except in the highest elevations; most precipitation comes in the form of rain.

Under historical, predevelopment conditions, flows in the mainstem would crest soon after rainstorm peaks. Approximately 80 percent of the annual discharge occurred during winter (Ritter and Brown 1971). Historic maximum winter flows were many times greater in magnitude than winter base flows, and far higher than summer flows, which often dropped to 20 cfs or less.

Facilities owned and operated by PG&E and USACE have altered historical flows in both the mainstem Russian River and Dry Creek. Surface water hydrology changed in terms of timing, frequency, magnitude, and duration of flows. A portion of the winter runoff is now stored behind dams for release during dry months. Average monthly flows decreased

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[1] Total Kjeldahl nitrogen is the sum of the ammonia-nitrogen and organic nitrogen present in the sample. It does not include the inorganic forms of nitrogen (i.e., nitrite and nitrate).

for winter/spring periods, and increased for summer/fall periods. Water imported to the basin substantially increased the amount of water available during the summer season.

From 1908 to 1922, diversions of Eel River water through the PVP to the East Fork Russian River boosted springtime flows, but did not augment late summer flows. Since construction of Scott Dam in 1922, flow in the Russian River downstream of the East Fork has been augmented by water from the Eel River, especially in the summer months. PG&E diverted approximately 159,000 AFY of water, on average, from the Eel River into the East Fork Russian River for power generation at the Potter Valley Project northeast of Ukiah, although less water is currently diverted.

Coyote Valley Dam influences mainstem flow patterns year-round. Dam operations diminish flood peaks, redistribute winter flows, and increase summer flows above Healdsburg by as much as 200 cfs.

Warm Springs Dam substantially modified flow in Dry Creek. Lake Sonoma is operated primarily for flood control, water supply, and recreation. Flood control operations reduce peak flood discharges on Dry Creek and the Russian River below Healdsburg. During stormflow events, Warm Springs Dam is operated to attempt to limit Russian River flows at Guerneville to less than 35,000 cfs.

Water stored behind Warm Springs Dam is released throughout the dry months to support downstream water demands of domestic, municipal, and industrial users. Minimum instream releases under D1610 are also made, in part, to support recreational users. D1610 is described in section 1.4.3 and the flows under D1610 are discussed in Section 3. Summer flows are substantially higher than the pre-project conditions, approximating 100 cfs or more. USGS flow records indicate that prior to the construction of the dam, Dry Creek went dry during the summer.

Augmented summer flows have increased the amount of water that flows to the Estuary, thereby altering it from historical conditions. Before construction of major water projects, mainstem flows often dropped to 25 cfs or less, and at times ceased altogether. Under these conditions, the Estuary likely remained closed to the ocean for weeks or months at a time. Currently, inflows to the Estuary could result in periodic flooding of low-lying properties. As a result, the barrier sandbar is artificially breached, exposing the Estuary to ocean tides (see Sections 1.4.4 and 3.4). Local fisheries experts believe artificial sandbar breaching and high Estuary inflows from the river have altered habitat conditions for listed fish species from historical conditions (CDFG 2002; J. Smith, San Jose State University pers. comm. 2001).

Groundwater hydrology has likely been altered by water development, although these changes are not documented. Bankfull and overbank flows are now less common in reaches influenced by flood control operations at Warm Springs Dam. Furthermore, extraction of groundwater is likely to result in localized effects. Such effects may have changed sections of the Russian River from a gaining reach (groundwater flows from adjacent aquifer adds to riverine flow) into a losing reach (water from river flows into aquifer, reducing river flow). At the same time, increased summer base flows have increased the height of water tables and the extent of saturated soils within mainstem channel banks.

2.1.3.1 Stream Gaging

The USGS collects stage and discharge data at 17 gages along the Russian River and various tributaries, and collects stage data only at an additional 5 gages. Historically, the USGS collected streamflow data at 16 gages besides the 22 currently in operation. USGS has also collected sediment data at eight sites and water quality data at five sites. Table 2-3 shows the average annual discharge at selected locations. Streamflow on the East Fork Russian River near Ukiah represents approximately 50 percent of the average annual flow expected at Hopland, 25 percent of the average annual flow at Healdsburg, and 15 percent of the average annual flow at Guerneville. Average annual discharge on Dry Creek since construction of Warm Springs Dam (period 1983 to 2001) is less than the unregulated (period 1960 to 1983) average annual flow condition. This difference could be due to different weather patterns or changes in irrigation demand between regulated and unregulated periods, and does not necessarily reflect changes due to operation of Warm Springs Dam.

Table 2-3 Average Annual Discharge at Selected Sites in the Russian River Watershed

Site[1]	Drainage Area (square miles)	Period of Record	Avg. Ann. Discharge[2] (cfs)
East Fk. RR near Ukiah	105	1911-1958	375
East Fk. RR near Ukiah	105	1958-2002	569[4]
RR near Hopland	362	1939-1958	733
RR near Hopland	362	1958-2002	659[4]
RR near Healdsburg	793	1939-1958	1,474
RR near Healdsburg	793	1958-2002	837[4]
RR near Guerneville	1,338	1939-1958	2,330
RR near Guerneville	1,338	1958-2002	1,046[4]
Dry Creek near Geyserville	162	1959-1983	342
Dry Creek near Geyserville	162	1983-2002	548[3]

1 Source: USGS gage data at stations near Ukiah, Hopland, Guerneville, and Geyserville.
2 Average annual discharge was calculated by averaging flows at each USGS gaging station.
3 1983 to 2002 represents the period Warm Springs Dam operations affected flow in Dry Creek.
4 1958 to 2002 represents the period Coyote Valley Dam operations affected flow in Russian River.

2.1.3.2 High Flows

The Russian River watershed responds rapidly to variations in rainfall, often resulting in flash floods. On February 17, 1986, peak flows were 26,100 cfs at Hopland, 71,100 cfs at Healdsburg, and 102,000 cfs at Guerneville. Peak flood flow on Dry Creek near Geyserville prior to regulation by Warm Springs Dam was 32,400 cfs on January 31, 1963, and after regulation, the peak flow was 7,600 cfs on January 8, 1995 (USGS gage data), which was almost entirely due to discharge from the Pena Creek tributary downstream of the dam.

During the rainy season (November through May), natural streamflow rather than reservoir releases accounts for most of the flow of the Russian River. Coyote Valley Dam has only a slight effect on winter flood flows at Healdsburg because it controls only 7 percent of the drainage area of the Russian River watershed (USACE 1986a). A study by the USACE in 1986 evaluated the effect of Coyote Valley Dam on the flood of 1964 (a 25-year flood-event). The results indicate that dam operations substantially affect flood peaks at Hopland (29-percent reduction), but have limited effects at Guerneville (7-percent reduction).

The 1.5-year recurrence interval flood (i.e., the flood flow that occurs on average every 1.5 years) is significant because the associated flows are most effective, over the long-term, in forming and maintaining channel morphologic characteristics (Leopold 1994). Typically, the bankfull stage (flows reach the floodplain elevation on most channels) has an approximate recurrence interval of 1.5 years in the annual flood series. Flows greater than the 1.5-year-flood event exceed the channel capacity and overflow the floodplain. The bankfull channel capacities at Ukiah, Hopland, and Guerneville are 7,000 cfs, 8,000 cfs, and 35,000 cfs, respectively (USACE 1986a). Table 2-4 shows the channel capacity and 1.5-year floods at two of these locations.

Table 2-4 Russian River Channel Capacity and 1.5-Year Flood

Location	Channel Capacity	1.5-Year Flow
Hopland	8,000 cfs	12,000 cfs
Guerneville	35,000 cfs	30,000 cfs

The 1.5-year flood at Hopland is approximately 12,000 cfs in the regulated condition and 14,500 cfs in the unregulated condition. By comparison, at Healdsburg the 1.5-year recurrence interval flood is nearly identical in the regulated and unregulated conditions (approximately 25,000 cfs). At Guerneville, the 1.5-year recurrence interval under regulated conditions (as influenced by both Coyote Valley Dam and Warm Springs Dam) is approximately 30,000 cfs, and under unregulated conditions is approximately 37,000 cfs.

In both the regulated and unregulated conditions, the 1.5-year flow at Hopland is greater than the 8,000-cfs channel capacity, and would result in over-bank flows. The 1.5-year regulated flow condition at Guerneville is approximately equivalent to the bankfull channel capacity. Thus, on average, every 2 out of 3 years the flow can be expected to result in one flood that is at least equal to, or greater than, the channel capacity in these reaches.

Warm Springs Dam has significantly reduced flood flows in Dry Creek to less than 25 percent of the pre-dam rates (Swanson 1992). For example, the floods of 1963 and 1986 (5,280 cfs) on Dry Creek were of comparable sizes, but flow regulation by Warm Springs Dam reduced the 1986 peak flood flow by approximately 83 percent (Swanson 1992). The 1.5-year flood was approximately 11,000 cfs before construction of the dam, but has been reduced to approximately 2,500 cfs under regulated conditions. A 5-year recurrence interval flood on Dry Creek was more than 24,000 cfs before regulation by Warm Springs Dam, and is approximately 7,500 cfs today.

2.1.3.3 Low Flows

On April 17, 1986, the SWRCB issued D1610 approving SCWA's appropriative water rights permit application and amending SCWA's existing permits (SWRCB 1986b). The permits issued by the SWRCB under SCWA's applications incorporated, as permit terms, an agreement between SCWA and the CDFG that specified the minimum flows necessary for instream beneficial uses on both Dry Creek and the Russian River (see Section 1.4.3). These permit terms dictate minimum flow in Dry Creek and in the Russian River. Flow regulation under D1610 is described in Section 3.

2.1.4 Historical Channel Dynamics and Sediment Transport

A number of activities have altered channel characteristics in the Russian River and Dry Creek. These activities include streamside and in-river gravel mining, channelization, flood control projects, removal of riparian vegetation, operation of dams and the PVP interbasin water transfers. In general, habitat has become less diverse and less favorable to native fish species (Hopkirk and Northen 1980). The amount of riparian vegetation in the Russian River watershed has greatly decreased since the early 1800s because of agricultural practices, livestock grazing, urban development, flood control, gravel mining, and road construction.

2.1.4.1 East Fork Russian River

There is approximately 0.8 miles of habitat in the East Fork Russian River between Coyote Valley Dam at Lake Mendocino and its confluence with the mainstem Russian River. There is a lack of gravel and cobble recruitment below the dam with some gravel deposition existing near the confluence. This section of river is characterized by channelized, vertical embankments downstream of the dam. There is a lack of instream cover and structure in this reach. Exotic species, including striped bass, have been observed below Coyote Valley Dam (B. Cox, CDFG, pers. comm. 2000). Striped bass have been stocked in Lake Mendocino, but reproduction has not been documented in the Upper Russian River.

2.1.4.2 Upper Reach Russian River

In the Ukiah Valley, the Russian River largely consists of high-velocity run-habitat. Here the river flows in a relatively straight channel and is lined with dense riparian vegetation. Gravel extraction occurs within the river channel and on the floodplain of the Ukiah Valley. Instream gravel mining and trapped sediments in Lake Mendocino on the East Fork caused up to 16 feet of channel bed degradation between the mid-1960s and the mid-1980s at the City of Ukiah, based on historic survey data (Swanson 1992). Based on sedimentation data provided by SCWA, Swanson (1992) estimated that Lake Mendocino had trapped, on average, 21,000 tons of gravel sized sediments annually.

Downstream of the Ukiah Valley, the Russian River enters entrenched reaches through Hopland to Cloverdale and the Sonoma-Mendocino County line before entering the 20-mile-long alluvial Alexander Valley. In the Alexander Valley, the river flows in a wide, shallow, sinuously braided channel that is laterally migrating, causing bank erosion (Swanson 1992). Gravel extraction occurs in-channel, and vineyard development has been taking place on the floodplain. Both degradation and aggradation have been measured at river cross-sections in the valley during the past 2 decades (Swanson 1992).

2.1.4.3 Middle Reach Russian River

The Russian River flows out of the Alexander Valley near the Jimtown Bridge and enters Digger Bend, a sinuous canyon where the channel is confined and bounded by alluvial terraces. Approximately 1 mile east of Healdsburg, the river enters a 10-mile-long alluvial valley (RM 33 to RM 23), known as the "Middle Reach." Dry Creek enters the Russian River approximately 1 mile downstream of Healdsburg, and the Wohler Bridge defines the lower boundary of the reach. In the Middle Reach, the Russian River is a generally straight channel that flows through a 2-mile-wide floodplain. Land use is dominated by vineyards and active or abandoned gravel extraction pits. In the Middle Reach between the Healdsburg Dam and the Wohler Bridge, the channel has the capacity to carry up to the 10-year-flood event. This capacity is due to a lowering of the channel bed by an average of 10 feet (Swanson 1992), and is a result of land-use practices, including grazing and agriculture since the early 1800s and intensive gravel mining since the 1940s. However, gravel mining protocols outlined in the ARM Plan are designed to balance the rate of aggradation and degradation (EIP 1994).

2.1.4.4 Dry Creek

Similar to the Middle Reach of the Russian River, Dry Creek has undergone considerable geomorphic changes, particularly since 1940, when intensive instream gravel extraction was occurring (Swanson 1992). Gravel extraction continued in Dry Creek until 1979. Severe erosion, degradation, and channel-widening occurred on Dry Creek during this period as a result of channel incision of the Russian River by 18 feet at the confluence and the instream gravel extraction on Dry Creek. Aerial photography also indicates vegetation encroachment on many bars and floodplain areas.

2.1.4.5 Lower Reach Russian River

Downstream of the Wohler Bridge, the Russian River flows westerly through a narrow valley bounded by mountains. The channel is relatively straight and deep, with a low floodplain where the town of Guerneville is situated on the north side of the river. Guerneville is subject to frequent flooding, on average once every 5 years. Gravel and sandbars are common along the channel. Below Guerneville, the Russian River flows into its coastal estuary near the confluence with Big Austin and Willow creeks.

2.1.4.6 Laguna de Santa Rosa and Mark West Creek

These tributaries to the Russian River are characterized as low-gradient, and at times, intermittent. Agriculture is common near the banks of Laguna de Santa Rosa and Mark

West Creek. A lack of canopy and instream cover results in high water temperatures. Portions of the banks are channelized for flood control and bank stabilization. Warmwater fish species are common in both streams (R. Benkert, SCWA, pers. comm. 2001).

2.1.4.7 Estuary

The Estuary near Jenner extends approximately 6 to 7 miles from the river's mouth at the Pacific Ocean, upstream to Duncans Mills and Austin Creek in western Sonoma County. Tidal influence has occurred as far as 10 miles upstream to Monte Rio (Russian River Estuary Interagency Task Force [RREITF] 1994). A barrier beach (sandbar) forms naturally across the mouth of the river periodically during the dry season, impounding water and forming a lagoon. The sandbar opens naturally when hydraulic conditions in the Russian River and Pacific Ocean change, or when it is artificially breached. When the sandbar is open, the Estuary is open to tidal mixing. A detailed description of the structure and function of the Estuary is presented in Section 3.4.

2.1.4.8 Other Tributaries

Remaining Russian River tributaries can be grouped into two geographic sets:
1) tributaries to the Estuary, and 2) tributaries to the mainstem above the Estuary. Habitat conditions for the tributaries in each set are discussed in the following sections.

Tributaries to the Estuary Reach

Tributaries to the Estuary include Willow Creek, Freezeout Creek, Dutch Bill Creek, Austin Creek, and their tributaries. These streams have been degraded from logging and grazing activities, but at one time they supported coho salmon and steelhead, as well as other species. Many of these streams maintain a grade-level connection with the mainstem. Habitat conditions in these streams are typified by excessive fine sediment and degraded riparian vegetation. Additionally, the stream morphology has been greatly altered by the deposition of excessive sediment in the lower-gradient reaches closest to the Russian River. Larger systems, such as Austin Creek and its tributaries, generally contain habitat that is in good condition. However, the mainstem of Austin Creek has been used for gravel extraction. In the past, many summer dams were installed every year in the watershed, but have since been removed. Dutch Bill Creek is parallel to the Bohemian Highway and numerous houses and businesses are situated along its length.

Many of these tributaries (Freezeout, Willow, and Austin creeks, and their tributaries) were surveyed for habitat conditions during summer and fall months from 1994 to 1996 (CDFG 1998b). Tributaries were slightly to moderately incised in their middle and upper reaches. Of the 60 to 70 surveyed miles of lower tributaries below Guerneville, 72.4 percent were classified as a Rosgen channel type F or G (Rosgen 1996), which are the likely natural channel types in this watershed. (F-type and G-type channels are low-gradient, meandering channels. G-type channels are steeper than F-channels and have a lower width-to-depth ratio.) This reach originally was likely a wide, shallow, braided channel (Swanson 1992). The overall dominant stream cover was mostly boulders, although root masses and woody debris were found in the upper tributaries. Canopy cover in the surveyed streams tended to be high, and of the 14 tributaries surveyed, nine had over 80 percent canopy cover and four had 50 percent to 80 percent cover. East Austin Creek was the only creek surveyed that had a canopy cover below 50 percent. Instantaneous water temperatures measured during the surveys ranged from a low of 46°F (8°C) to a high of 76°F (24°C). Summer maximum water temperatures averaged in the mid-60s°F. The percentage of pools based upon stream length ranged from 32 percent in Freezeout Creek to 6 percent in Ward and Mission creeks. The average pool-habitat of all surveyed tributaries was 22 percent.

Tributaries to the Mainstem above the Estuary

Santa Rosa Plain Tributaries

The streams of the Santa Rosa plain include Laguna de Santa Rosa, and Atascadero, Mark West, Santa Rosa, and Windsor creeks, and their tributaries. These tributaries drain the area to the south and east of the Russian River between Guerneville and Healdsburg. Most of these tributaries flowing across the Santa Rosa plain are low-gradient streams, and because urbanization has occurred in the area, many are managed as flood control channels. Habitat quality here is poor as a result of levees, armored stream banks, dredging activities, past practices of removing riparian vegetation, and warm summer water temperatures. Tributaries to the Middle Reach of the Russian River between Healdsburg and the Wohler Bridge, where gravel mining occurs, have undergone incision in their lower reaches as the mainstem has incised at some locations.

Streams in the Mark West Creek watershed and their tributaries were surveyed during summer and fall months of 1994 to 1996 (CDFG unpublished data, CDFG 1998b). The surveys found that the Santa Rosa plain tributaries had incised channels. Half of the 48.3 miles surveyed were classified as well-entrenched, low-gradient stream. Instantaneous water temperatures measured during the surveys in the Santa Rosa plain tributaries during July through November ranged from 50°F to 74°F (10.0°C to 23.3°C). Summer maximum water temperatures averaged in the mid-60s°F (approximately 18°C). Canopy cover was relatively high, ranging from 60 percent to 90 percent. Dominant stream cover varied, and included boulders, aquatic vegetation, and root masses. In the streams surveyed, the ratio of pool-habitat to stream length varied from 6 percent to 47 percent. The tributaries of the Santa Rosa plain consisted of an average of 27 percent pool habitats. Habitat quality in upper Santa Rosa Creek and Mark West Creek in the foothills east of Santa Rosa was excellent.

Middle Reach Tributaries

Major tributaries of the Middle Reach of the Russian River include Maacama, Sausal, Big Sulphur, and Dry creeks. Most of the tributaries on the west side of the Middle Reach are minor streams, except for Dry Creek and its tributaries. Dry Creek and its lower tributaries, Felta and Mill creeks, have undergone incision in their lower reaches as a result of mining-induced incision of the Russian River channel and other activities.

Fish population surveys and site-specific habitat assessments were conducted in Sausal and Big Sulphur creeks in the mid-1970s (PG&E 1975). More recently, habitat surveys were conducted on west- and east-side tributaries (Maacama and its tributaries, Felta and Mill creeks, and Palmer Creek and its tributaries) during the summer and fall months of 1996 to 1997 (CDFG 1998b). Habitat in more than 61 percent of the 33.7 miles of tributaries in the Middle Reach showed indications of incision. This incision occurred mainly in the lower reaches of these tributaries. These channels were characterized by multiple channels with very high width-to-depth ratios in the lower reaches of Maacama Creek. This type of channel offers poor quality habitat and may interfere with fish migrating into the system. Instantaneous water temperatures measured during the surveys ranged from 49°F to 80°F (9.4°C to 26.7°C) from June through November. Summer maximum water temperatures averaged in the mid-60s°F. The dominant cover type consisted of boulders and some root masses. The average percentage of pool based on stream length ranged from 5 percent to 55 percent, with an average of 27 percent. Canopy cover for the surveyed streams in the Middle Reach ranged from 48 percent in Maacama Creek to 91 percent in Thornton Creek. Most of these tributaries had canopy covers greater than 50 percent.

<u>Upper Reach Tributaries</u>

Comminsky, Pieta, McNab, Robinson, Feliz, McClure, Ackerman, and Forsythe creeks and the East Fork are the main tributaries of the upper reach of the Russian River, upstream from the Mendocino-Sonoma County line. Most of the East Fork Russian River lies upstream of Coyote Valley Dam. Pieta Creek was sampled for fish populations and habitat characteristics in the mid-1970s (PG&E 1975). More recently, McNab, Robinson, and Ackerman creeks were surveyed for aquatic habitat during the summer to early winter months from 1994 to 1997 (CDFG 1998b). The aquatic habitat survey found that over 60 percent of the channels were incised. Between June and December, instantaneous water temperatures ranged from 51°F to 77°F (10.6°C to 25.0°C). Summer maximum water temperatures during the surveys averaged in the mid-60s°F (approximately 18°C). Dominant substrate for these streams is mainly gravel in the lower reaches, and cobble, boulders, and bedrock in the upper reaches. The dominant cover in Ackerman and Robinson creeks is boulders, and the dominant cover in McNab Creek is root masses. The average pool-habitat ratio based on stream length for the three creeks is 24 percent (ranges from 19 percent to 30 percent).

2.1.5 Habitat Conditions in the Russian River Watershed

Habitat conditions have been assessed within portions of the watershed over the last few decades. The most recent information comes from stream-habitat surveys conducted by CDFG and cooperating agencies such as SCWA. The CDFG Draft Basin Restoration Plan for the Russian River (2002) lists priorities for restoration based on stream inventory data. Streams that can support coho salmon are given first priority in this plan. Much of the watershed is privately owned, and restoration efforts depend on local landowner cooperation.

Gravel and streamflow conditions suitable for salmonid spawning are prevalent in the Russian River mainstem and tributaries (Winzler and Kelly 1978). In the lower and middle mainstem (below Cloverdale) and the lower reaches of tributaries, loss of riparian vegetation and changes in stream morphology have reduced much of the cover. As a result, summer water temperatures exceed 55°F (13°C) by April in some years (Winzler and Kelly 1978), limiting the habitat use in these areas. However, steelhead have been observed utilizing summer habitat as far downstream as Healdsburg (Cook 2003a; Chase et al. 2000, 2001, 2003). Results of a flow-habitat study conducted in the fall of 2001 in the mainstem and in Dry Creek are presented in Appendix F.

The most urbanized portion of the watershed is in Santa Rosa and the Cotati-Rohnert Park areas. These areas contain most of the constructed flood control channels. Natural streams and constructed channels in the Rohnert Park area are generally low-gradient and run through a valley plain from the foothills to the east. Poor summer water quality and low summer flows limit rearing habitat in this region. Stream surveys conducted by the CDFG and by SCWA indicate that approximately 45 to 60 percent of the Laguna de Santa Rosa watershed may be characterized as moderately degraded, and approximately 25 percent as severely degraded (S. White, SCWA, pers. comm. 2002b). However, the Laguna de Santa Rosa has important wetland and flood control functions for this part of the watershed. Santa Rosa Creek drains to the Laguna de Santa Rosa, which, in turn, drains to Mark West Creek. The upper portion of the Mark West Creek watershed, including the Santa Rosa Creek watershed, contains good steelhead rearing and spawning habitat. Much attention has been given in recent years to restoration opportunities in this area.

The western side of the Russian River valley is cooler, subject to coastal fog in the summer, and supports coniferous forest. Some of the best coho salmon spawning and rearing habitat occurs in tributaries in this region. Good quality coho salmon habitat also occurs in the tributaries of the upper portion of the Russian River watershed. In addition, parts of the Mark West and Maacama Creek watersheds contain good coho salmon rearing and spawning habitat.

The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable rearing habitat for steelhead. These areas generally have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing.

Historic spawning distribution of Chinook salmon in the Russian River watershed has not been documented. Suitable habitat exists in the upper mainstem and in low-gradient tributaries, including Dry Creek. A Chinook salmon redd survey was conducted in the mainstem in 2002 and 2003 (see Section 2.2.3).

2.1.5.1 Lake Mendocino

Lake Mendocino contains a non-native, warmwater fishery, and some non-native fish are potential predators of salmon and trout. Non-native predators may escape from the reservoir and may seed downstream habitat when the reservoir spills or releases are made. Nearshore regions in the reservoirs are affected by drawdowns due to water supply releases. When the lake levels are low, CDFG biologists have historically placed dead brush along the nearshore region to provide spawning and rearing habitat in the reservoir.

Lake Mendocino does not provide habitat for native anadromous salmonids because the dam is not passable. “Resident” trout may be present upstream of the lake. These fish may also escape from the reservoir if Lake Mendocino spills.

2.1.5.2 Lake Sonoma

Historically, the basin flooded by Lake Sonoma was heavily forested with a combination of riparian woodland, oak woodland, and redwood-Douglas fir forest. The nearshore region of the reservoir provides the primary habitat for non-native warmwater species for spawning and juvenile rearing. Some of these species are potential predators of salmon and trout and may seed downstream habitat when spills or releases occur.

Lake Sonoma’s water levels currently experience large and rapid fluctuations of 5 feet to 10 feet per month. These fluctuations are the result of runoff collected in the lake, and reservoir releases made for water supply and flood control operations. Because Lake Sonoma has a steeply sloped bottom, the area of shallow water habitat, which is less than 15 feet, decreases as the reservoir level decreases (SCWA 1998a). Because spawning and rearing of most warmwater fish occur near shore, large changes in reservoir levels during spring and summer negatively affect these fish.

2.1.6 Water Quality

Overall water quality in the Russian River Basin was discussed in Section 2.1.3. Water temperature is a key water quality factor that affects salmonid habitat. Activities within the basin also have the potential to affect DO. Sediment loads within the river may affect turbidity, which can affect the feeding ability of salmonids. These important water quality parameters are discussed in greater detail below.

2.1.6.1 Water Temperature

Water temperature is one of the most important factors controlling production and distribution of fish in streams. Water temperature directly affects an organism's ability to survive, grow, and reproduce. Within a species-specific tolerance range, as water temperature increases, an organism’s growth rate and physiological performance (e.g., swimming ability) increases. Water temperatures above this tolerance range result in both a reduction in growth and in overall physiological performance, and an increased susceptibility to disease. Ultimately, excessively high temperatures can result in direct mortality. Factors such as DO levels and food availability affect temperature tolerance of salmonids. However, given adequate food transport and suitable habitat, steelhead may grow well in temperatures that are higher than the optimal temperatures reported in literature, which are generally based on northern stocks (Smith and Li 1983). Optimal and lethal water temperature tolerances vary by species and by lifestage (e.g., salmonid embryos are less tolerant of high temperatures than juveniles).

There are no site-specific temperature tolerance data on the effects of temperature on coho salmon, steelhead, and Chinook salmon in the Russian River. Stream temperatures that restrict salmonids vary with species and apparently by geographical region. Critical temperatures that limit production and survival of coho salmon, steelhead, and Chinook salmon vary widely in the literature.

NCRWQCB is reviewing and revising the water quality objective for temperature in the Russian River basin to protect aquatic life, including listed species in the Russian River. This process includes an in-depth analysis of salmonid water temperature tolerances. NCRWQCB's recommended standards are currently in draft form (NCRWQCB 2000). Water temperature criteria for coho salmon, steelhead, and Chinook salmon are presented in Appendix C, *Evaluation Criteria*.

Little is known about water temperatures in the Russian River before the arrival of non-indigenous people. Natural warming generally occurs in a downstream direction, and mainstem in the lower watershed, as well as lower reaches of some tributaries, may have been warm enough to support a native warmwater fish community. Warm-season water temperatures have likely been reduced in reaches below Lake Mendocino and Lake Sonoma due to coldwater releases from these reservoirs. During summer, water temperatures in the Russian River and Dry Creek generally increase with distance downstream from reservoirs; water temperatures in the lower sections of both streams are generally 10°F to 20°F (6°C to 11°C) warmer than in the upper sections (Winzler and Kelly 1978, Prolysts and Beak Consulting 1984).

Lake Mendocino is usually thermally stratified between March and September. During the months that thermal stratification occurs, water temperatures in the bottom layers of the reservoir are much cooler than in surface layers, because they represent water stored during spring runoff that was insulated from warming by the epilimnion. (The epilimnion is the upper layer of a stratified lake that is warmer and consequently less dense so that it floats over a denser, cooler water layer beneath.) The epilimnion is warmed by the sun and becomes too warm for salmonids during the summer. Releases from Lake Mendocino are made from the bottom layer of the lake (hypolimnion) and are cool as long as thermal gradients are present. However, by the end of the summer when the coldwater pool may be drawn down, water temperatures may be warmer. During June, water temperatures immediately below Lake Mendocino average 55°F (12.8°C). By September, the release water is slightly warmer than the water upstream of the lake (Baum 2003a). In late September or early October, when lake stratification begins to break down, temperatures in releases from the reservoir are in the low 70ºF range. This occurs when Chinook salmon begin entering the system and move upstream.

During late spring and early summer, water temperatures in the uppermost portion of the river, and its tributaries, are optimal for salmonids. During late summer, temperatures become stressful along portions of the mainstem river. Water temperatures generally increase in a downstream direction. Summer temperatures in portions of the Russian River and in many of its tributaries exceed published optimal ranges for salmon and steelhead, particularly during daytime, and may reach lethal levels under certain hydrologic and meteorological conditions (Winzler and Kelly 1978, PG&E 1979).

(However, water temperature thresholds in published literature are based on studies in the Northwest Pacific and may not be appropriate for the Russian River basin.)

Lake Sonoma is thermally stratified during summer months. The epilimnion becomes too warm for salmonid species. A warmwater fishery was established in the reservoir for recreational anglers. The temperature of water released from Lake Sonoma, which is controlled by drawing water from different lake depths, rarely exceeds 60°F (15.6°C). This produces approximately a 4°F decrease in summer temperatures in the Russian River below the Dry Creek confluence (NCRWQCB 1993a, USACE unpublished 1999b). Because release water can be drawn from multiple depths in the lake, and because Lake Sonoma is deeper and has a larger cold water supply, the coldwater layer in the lake is not as likely to be depleted by the end of the summer as it is in Lake Mendocino.

In 1995, SCWA funded development of a water temperature model encompassing Lake Sonoma, Dry Creek below Warm Springs Dam, and the Russian River below Coyote Valley Dam (Resource Management Associates [RMA] 1995). Results of the model under current flow conditions are presented in Section 3.

Summer temperatures in many of the Russian River tributaries exceed the optimum temperature ranges for salmon and steelhead. Temperature recorders placed in Santa Rosa and Mark West creeks indicate that summer temperatures in these streams are suitable for salmonids during the summer, except in the more downstream reaches (SCWA 2003a). Other tributaries, such as Big Sulphur Creek, have summer water temperatures that may be too warm for salmonids in their lower reaches (PG&E 1975). However, many tributaries in the rest of the watershed maintain suitable temperatures for salmonids.

2.1.6.2 Dissolved Oxygen

Growth rates, embryonic development, and fish activity can be limited by a reduction of DO. DO levels vary according to temperature, elevation, the presence of aquatic plants or other aquatic species, and turbulence in the water. DO levels are especially important during egg incubation. Embryos require relatively high intergravel oxygen concentrations for successful development, which must be maintained by oxygenated flow through spawning gravels. Salmonid species require DO levels between 7 to 9 milligrams per liter (mg/l). During the 1977 drought, DO in the lower Russian River dropped as low as 5.4 mg/l, but recorded levels have otherwise remained above 7 mg/l (SCWA 1980).

The hypolimnion (deep-water layer) of Lake Mendocino contains little or no DO during summer, so the water released into the river from deep-water intakes has little DO. However, oxygen is replenished within a few hundred yards of the dam by turbulent mixing (SCWA 1980).

The City of Ukiah operated a liquid oxygen injection ring at the Coyote Valley Dam outlet to maintain DO in release water at or above 7 mg/l, at 7.5 mg/l at least 90 percent of the time, and at a monthly median of 10 mg/l for the year. In 1997, the City of Ukiah discontinued oxygen injection after monitoring showed the system was ineffective and minimum oxygen requirements could be maintained from turbulence in the bypass valves in the piping system. Water released from Lake Sonoma passes over a flip bucket at the outlet works, while water diverted to and through the fish hatchery passes through a series of aeration ponds prior to release into Dry Creek. These measures maintain DO at suitable levels.

2.1.6.3 Turbidity

Turbidity is caused by fine particulate materials, both inorganic and organic, suspended in water. Scattering and reflection of light by these particles reduce penetration of light, resulting in reductions of primary production and visibility. Reduced primary production may affect DO levels and diminish food and cover for fish and aquatic macroinvertebrates (Lloyd et al. 1987). The Russian River and its tributaries are typically more turbid during winter and spring when runoff is highest. Erosion rates have likely been influenced by activities such as timber harvest practices, agricultural development, grazing by livestock, removal of riparian vegetation for flood control, streamside gravel mining, urban development, and road construction.

Turbidity in the mainstem Russian River above Dry Creek increases in response to releases of highly turbid water from Lake Mendocino in the winter- and spring-runoff period (Ritter and Brown 1971).

In some cases, reservoirs trap suspended sediments carried in storm flows, thereby decreasing concentrations of suspended sediments in downstream releases. However, reservoirs produce phytoplankton that elevate turbidities above levels found in in-flowing waters.

Sedimentation is the settling-out of suspended materials from the water. Sedimentation occurs mainly in lakes, reservoirs, and in low-velocity areas of stream channels. Sedimentation can reduce gravel quality and the success of salmon and steelhead spawning, egg incubation, newly emerged salmonids (fry), and insect survival. Female salmon and steelhead, while digging redds (nests) in the gravel, will release fine sediments into the water column where the higher water velocities will carry the sediments downstream. However, when high levels of silt settle on a redd after spawning, eggs can “smother” and die from lack of oxygen. Dead eggs can promote the growth of fungus, which may spread throughout the entire redd.

High winter flows can flush sand and fine sediments from gravel. However, Coyote Valley Dam and Warm Springs Dam have generally reduced the frequency and duration of winter peak flows. Effects of flood control operations are discussed in Section 3.

2.2 BIOLOGICAL RESOURCES

The following sections describe the Russian River fish community and the life-histories and migratory behaviors of coho salmon, steelhead, and Chinook salmon in the Russian River. Information is presented on the distribution and abundance of listed fish species as well as on the genetic variance within and between populations.

To assess the effects of baseline activities and provide data for evaluation in this BA, SCWA instituted a series of studies on the biology of the listed species and on project operations under baseline conditions. Pilot studies were also conducted to assess potential modifications to baseline activities. The data resulting from these studies are presented throughout this document to characterize and evaluate baseline project activities.

2.2.1 RUSSIAN RIVER FISH COMMUNITY

The Russian River and its Estuary support a community of fish species that includes both resident and anadromous species, as well as native and introduced species (Table 2-5). To date, 29 species, including 16 native species, have been collected or observed during SCWA monitoring activities in the lower Russian River during the 1999 and 2000 sampling seasons. Three species not documented during SCWA monitoring activities have been historically reported and recorded in the Russian River: white sturgeon, green sturgeon, and pink salmon. Historically, white and green sturgeon occasionally entered the Russian River, although these species apparently did not spawn or rear their young in the river. Stray pink salmon and chum salmon may occasionally be seen but are not known to reproduce in the Russian River (Hopkirk and Northen 1980; S. White, SCWA, pers. comm. 2003c). Abundant resident species inhabiting the mainstem Russian River include smallmouth bass, Sacramento sucker, hardhead, tuleperch, and California roach (Chase et al. 2000, 2001, 2002, 2003; Cook 2003a).

Streams typically exhibit a gradation in habitat types longitudinally as they flow from their headwaters downstream (Moyle and Nichols 1973). Fish populations change in response to habitat conditions. Two important factors affecting the distribution of fish are water temperature and stream gradient. Changes in the watershed that affect water temperature (primarily alterations to the riparian habitat) influence the longitudinal position where the thermal regime becomes unsuitable for salmonids. Moyle and Nichols (1973; Moyle 1976, 2002) described four freshwater fish zones and a fifth estuarine zone for the Sacramento-San Joaquin river systems. The five zones are the Rainbow Trout Zone, the California Roach Zone, the Squawfish (pikeminnow)-Sucker-Hardhead Zone, the Deep-bodied Fish Zone, and the Estuarine Zone. The borders between fish zones are not distinct, but gradually shift from one zone to another in response to changes in habitat.

Sampling conducted in tributaries to the Russian River (Santa Rosa, Millington, and Mark West creeks) between 1999 and 2001 as part of SCWA's Population Monitoring Pilot Study (Chase et al. 2003) (described in Section 2.2.4) indicates that the fish community in the Russian River basin forms analogous aggregations to those described by Moyle and Nichols (1973; Moyle 1976, 2002). In general, species composition in the larger creeks is dominated by steelhead and sculpin in the upper reaches, with California roach becoming important in the middle reaches (Chase et al. 2003). In lowland tributary channels, California roach, sculpin, and Sacramento sucker are the dominant species (Chase et al. 2003). Moyle (1976) describes the Rainbow Trout Zone as headwater streams with relatively high gradients, and cold (seldom greater than 21°C), well-oxygenated water. Fish communities in this zone are dominated by rainbow trout, although sculpin are often found in the lower portions of the zone. Upper Mark West and

Table 2-5 Fishes of the Russian River Watershed

Family	Scientific Name	Common Name	Status
Acipenseridae	*Acipenser transmontanus*	white sturgeon	Native
	Acipenser medirostris	green sturgeon	Native
Catostomidae	*Catostomus occidentalis*	Sacramento sucker[1]	Native
Centrarchidae	*Lepomis macrochirus*	bluegill[1]	Introduced
	Lepomis cyanellus	green sunfish[1]	Introduced
	Lepomis microlophus	redear sunfish	Introduced
	Pomoxis annularis	white crappie[1]	Introduced
	Micropterus dolomuieu	smallmouth bass[1]	Introduced
	Micropterus salmoides	largemouth bass[1]	Introduced
Clupeidae	*Alosa sapidissima*	American shad[1]	Introduced
Cottidae	*Cottus asper*	prickly sculpin[1]	Native
	Cottus gulosus	riffle sculpin[1]	Native
Cyprinidae	*Lavinia symmetricus*	California roach[1]	Native
	Mylopharodon conocephalus	hardhead[1]	Native
	Orthodon microlepidotus	California blackfish[1]	Native
	Lavinia exilicauda	hitch[1]	Native
	Ptychocheilus grandis	pikeminnow[1]	Native
	Pimephales promelas	fathead minnow[1]	Introduced
	Notemigonus crysoleucas	golden shiner[1]	Introduced
	Cyprinus carpio	carp[1]	Introduced
Embiotocidae	*Hysterocarpus traski*	Russian River tuleperch[1]	Native
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback[1]	Native
Ictaluridae	*Ameiurus catus*	white catfish[1]	Introduced
	Ameiurus spp.	bullhead[1]	Introduced
	Ictalurus punctatus	channel catfish	Introduced
Percichthyidae	*Morone saxitalis*	striped bass[1]	Introduced
Petromyzontidae	*Lampetra tridentata*	Pacific lamprey[1]	Native
	Lampetra richardsoni	western brook lamprey[2]	Native
		river lamprey[3]	
Poecillidae	*Gambusia affinis*	mosquitofish[1]	Introduced
Salmonidae	*Oncorhynchus tshawytscha*	Chinook salmon[1]	Native
	Oncorhynchus keta	chum salmon[1]	Native/Stray
	Oncorhynchus mykiss	steelhead[1]	Native
	Oncorhynchus kisutch	coho salmon[1]	Native
	Oncorhynchus gorbuscha	pink salmon	Stray

[1] Observed during SCWA monitoring activities in the Russian River during the 1999 and 2003 sampling seasons.
[2] Observed during SCWA monitoring activities in the Russian River during 2002 sampling season.
[3] Caught by Merritt Smith Consulting.
Sources: Cook 2003a; Cook and Manning 2002; Chase et al. 2001; Chase et al. 2000; Chase et al. 2003; Hopkirk and Northen 1980.

Santa Rosa creeks are analogous to the Rainbow Trout Zone. The California Roach Zone is typified by warm, intermittent streams. California roach is the dominant species in the middle section of Mark West Creek and below Highway 12 on Santa Rosa Creek.

The Squawfish (pikeminnow)-Sucker-Hardhead Zone is found in the mainstem Russian River (Chase et al. 2001), but riffles in the upper reach have been observed to be dominated by rearing steelhead with few, if any, pikeminnow, suckers, or hardhead (SCWA 2002, unpublished data). However, pikeminnow may move into the riffles at night to feed.

Abundant species in the Estuary include threespine stickleback, topsmelt, prickly sculpin, starry flounder, and staghorn sculpin (SCWA 2001b; J. Roth, pers. comm., as cited in Resource Management International, Inc. [RMI] 1997). Other species observed during monitoring activities (including otter trawl and beach seine sampling) at the Estuary are listed in Table 2-6 (Merritt Smith Consulting [MSC] 1997a, 1997b, 1998, 2000; SCWA 2001b).

2.2.2 LIFE-HISTORIES AND MIGRATORY BEHAVIORS OF COHO SALMON, STEELHEAD, AND CHINOOK SALMON

Coho salmon, steelhead, and Chinook salmon are anadromous species (although steelhead may also exhibit a life-history type that spends its entire lifecycle in fresh water). These species migrate upstream from the ocean as adults and spawn in gravel substrate. Their eggs incubate for a short period, depending on water temperature, and generally hatch in the winter and spring. Juveniles spend varying amounts of time rearing in the streams and then migrate out to the ocean.

2.2.2.1 Coho Salmon

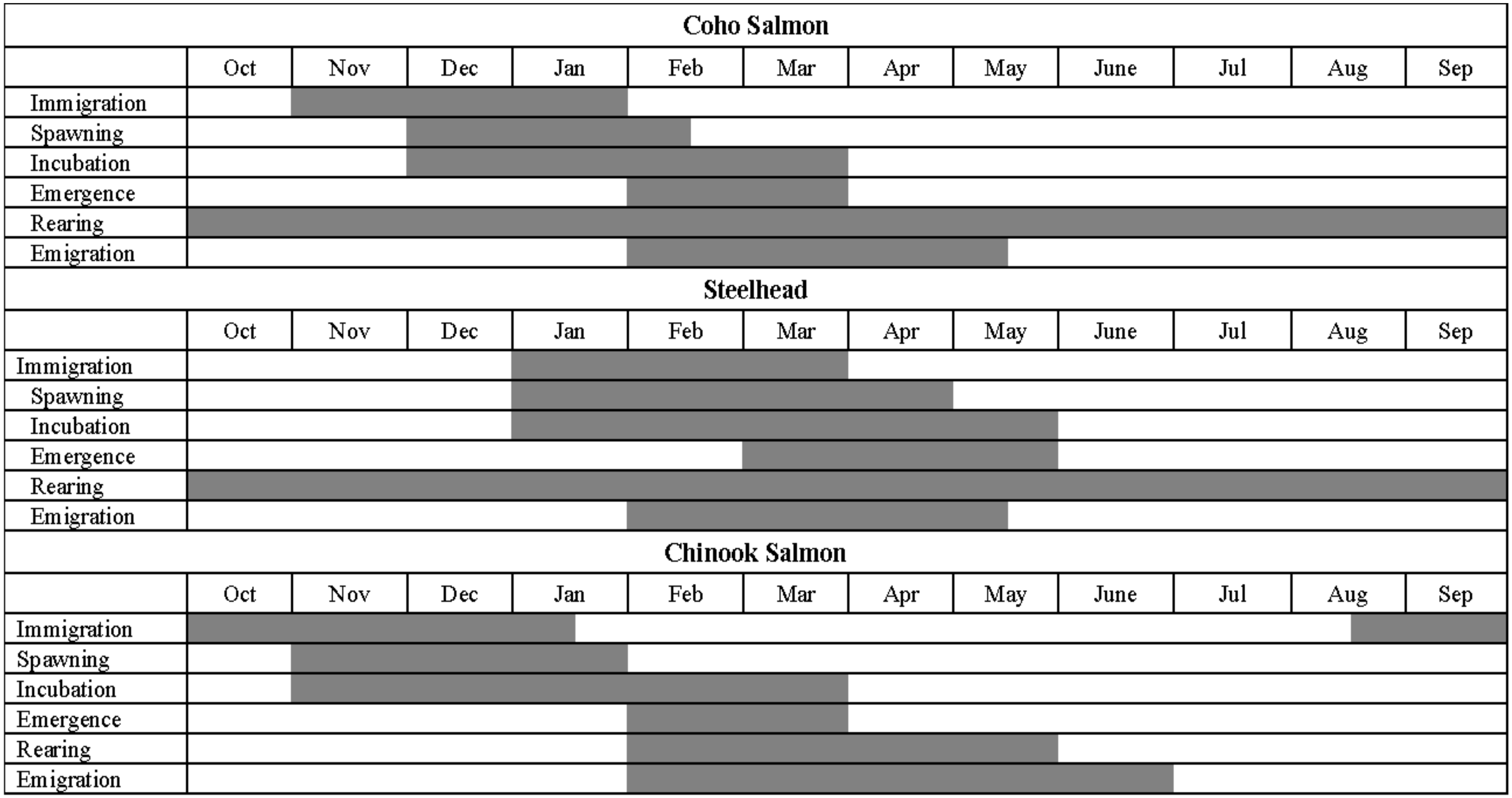
The coho salmon life-history is quite rigid, with a relatively fixed 3-year lifecycle. The best available information suggests that life-history stages occur during times shown in Figure 2-3 (Chase et al. 2000 to 2003; Hopkirk and Northen 1980; Moyle 1976; Moyle et al. 1989; Steiner Environmental Consulting 1996). Most coho salmon enter the Russian River in November and December and spawn in December and January. Spawning and rearing occur in tributaries to the lower Russian River. The most upstream tributaries with coho salmon populations included Forsythe, Mariposa, Rocky, Fisher, and Corral creeks, but coho salmon have not been found in these streams in recent years (see Section 2.2.3). The mainstem below Cloverdale serves primarily as a passage corridor between the ocean and the tributary habitat.

After hatching, young coho salmon spend approximately 1 year in fresh water before they become smolts (undergo a physiological change for adaptation to seawater) and migrate to the ocean. Freshwater habitat requirements for coho salmon rearing include adequate cover, food supply, and suitable water temperatures. Primary habitat for coho salmon includes pools with extensive cover. Outmigration takes place in late winter and spring. Coho salmon live in the ocean for a year and a half, return as 3-year-olds to spawn, and then die. The factors most limiting to juvenile coho salmon production are not completely

Table 2-6 Fish Species Observed in the Russian River Estuary, 1992 to 2000

Family	Scientific Name	Common Name	Status
Atherinidae	*Atherinops affinis*	Topsmelt	Native
Bothidae	*Citharichthys sordidus*	Pacific sanddab	Native
	Citharichthys stigmaeus	speckled sanddab	Native
Catostomidae	*Catostomus occidentalis*	Sacramento sucker	Native
Centrarchidae	*Lepomis cyanellus*	green sunfish	Introduced
	Lepomis macrochirus	Bluegill	Introduced
	Micropterus dolomieui	Smallmouth bass	Introduced
Clupeidae	*Clupea harengus pallasii*	Pacific herring	Native
Cottidae	*Artedius lateralis*	Smoothhead sculpin	Native
	Artedius notospilotus	bonyhead sculpin	Native
	Cottus asper	prickly sculpin	Native
	Enophrys bison	buffalo sculpin	Native
	Enophrys taurina	bull sculpin	Native
	Leptocottus armatus	staghorn sculpin	Native
	Scorpaenichthys marmoratus	Cabezon	Native
	Sebastes paucispinis	Bocaccio	Native
	Sebastes melanops	black rockfish	Native
Cyprinidae	*Cyprinus carpio*	carp	Introduced
	Lavinia symmetricus navarroensis	Navarro roach	Native
	Mylopharodon conocephalus	hardhead	Native
	Ptychocheilus grandis	Sacramento pikeminnow	Native
Embiotocidae	*Cymatogaster aggregata*	shiner surfperch	Native
	Hyperprosopon anale	spotfin surfperch	Native
	Hyperprosopon argenteum	walleye surfperch	Native
	Hyperprosopon ellipticum	silver surfperch	Native
	Hysterocarpus traskii	Russian River tuleperch	Native
Engraulididae	*Engraulis mordax*	northern anchovy	Native
Gadidae	*Gadus macrocephalus*	Pacific tomcod	Native
Gasterosteidae	*Gasterosteus aculeatus*	threespine stickleback	Native
	Aulorhynchus flavidus	tube-snout	Native
Gobiesocidae	*Gobiesox maendricus*	northern clingfish	Native
Gobiidae	*Clevelandia ios*	arrow goby	Native
Hexagrammidae	*Hexagrammos decagrammus*	kelp greenling	Native
	Ophiodon elongatus	lingcod	Native
Osmeridae	*Hypomesus pretiosus*	surf smelt	Native
	Spirinchus thaleichthys	longfin smelt	Native
Pleuronectidae	*Isopsetta ischyra*	hybrid sole	Native
	Parophrys vetulus	English sole	Native
	Platichthys stellatus	starry flounder	Native
	Psettichthys melanostictus	sand sole	Native
Pholididae	*Pholis ornata*	saddleback gunnel	Native
	Apodichthys flavidus	penpoint gunnel	Native
Poecillidae	*Gambusia affinis*	Mosquitofish	Introduced
Salmonidae	*Oncorhynchus mykiss*	Steelhead	Native
	Oncorhynchus tshawytscha	Chinook salmon	Native
Sciaenidae	*Genyonemus lineatus*	white croaker	Native
Syngnathidae	*Syngnathus griseolineatus*	bay pipefish	Native

Source: SCWA 2001b.



References: Hopkirk and Northen (1980); Moyle (1976); Moyle et al. (1989); Steiner Environmental Consulting (1996); Chase et al. (2000 to 2003).

Figure 2-3 Phenology of Coho Salmon, Steelhead, and Chinook Salmon

understood, but may include high water temperatures, poor summer and winter habitat quality, and predation.

2.2.2.2 Steelhead

Unlike coho salmon, steelhead do not have a fixed 3-year lifecycle. Steelhead spend 1 to 2 years in the ocean before returning to spawn for the first time, and may return to the ocean and spawn again in a later year. Adult steelhead generally begin returning to the Russian River with the first heavy rains of the season in November or December, and continue to migrate upstream into March or April. Adult steelhead have been observed in the Russian River during all months (S. White, SCWA, pers. comm. 1999). However, the peak migration period tends to be January through March (Figure 2-3).

Flow conditions are suitable for upstream migration in most of the Russian River and larger tributaries during the majority of the spawning period in most years. Sandbars blocking the river mouth in some years may delay entry into the river. However, when the sandbar is closed, the flow may be too low and water temperature too high to provide suitable conditions for migrating adults farther up the river (CDFG 1991).

Most steelhead spawning takes place from January through April, depending on the time of freshwater entry (Figure 2-3). Steelhead spawn and rear in tributaries from Jenner Creek near the mouth to upper basin streams, including Forsythe, Mariposa, Rocky, Fisher, and Corral creeks. Low numbers of wild and hatchery juvenile steelhead were observed in the Russian River near Wohler Pool during the first 3 years of sampling for SCWA's inflatable dam/Wohler Pool Fish Sampling Program, but more substantial numbers were documented in 2002. Snorkel surveys in sites throughout the mainstem in the summer and fall of 2002 documented more substantial steelhead numbers, mostly above Cloverdale but also as far downstream as Healdsburg (Cook 2003b).

Distribution of steelhead was correlated with water temperatures (Cook 2003b). The highest temperatures occurred in the Alexander Valley and Healdsburg reaches (25ºC and 24ºC, respectively). Although maximum temperatures were as high as 22ºC and 22.5ºC in the Ukiah and Canyon reaches, respectively, steelhead observed in these reaches during diver surveys appeared healthy and vigorous. Based on these observations, it appears that steelhead may rear in suitable habitat within the mainstem Russian River through the summer.

After hatching, steelhead usually spend 2 years in fresh water, but can spend 1 to 4 years. Fry and juvenile steelhead are extremely adaptable in their habitat selection.

Requirements for steelhead rearing include adequate cover, food supply, and suitable water temperatures. The mainstem above Cloverdale and upper reaches of the tributaries provide the most suitable habitat; generally, these areas have excellent cover, adequate food supply, and suitable water temperatures for fry and juvenile rearing. The lower reaches of some tributaries provide less cover; these streams are often wide and shallow, have little riparian vegetation, and water temperatures are often too warm to support steelhead. In the summer, these areas can completely dry up. Available cover has been reduced in much of the mainstem and in many tributaries due to loss of riparian vegetation and changes in stream morphology.

Emigration usually occurs between February and June, depending on flow and water temperatures. Steelhead smolts emigrate through the Wohler Pool at an average size of approximately 175 millimeter (mm) fork length (FL) (range 83 mm to 250 mm) (Chase et al. 2001). Sufficient flow is required to cue smolt downstream migration. Excessively high water temperatures in late spring may inhibit smoltification in late migrants.

2.2.2.3 Chinook Salmon

Adult Chinook salmon begin returning to the Russian River as early as late August, but most upstream migration occurs in October and November (Chase et al. 2001, 2002).

Chinook salmon may continue to enter the river through December and spawn into January (Figure 2-3). Adult Chinook salmon migrate upstream to their spawning habitat, located primarily in the mainstem Russian River above Asti and in selected tributaries such as Dry Creek.

Unlike coho salmon and steelhead, the young Chinook salmon begin their outmigration soon after emerging from the gravel. Freshwater residence in coastal California stocks, including outmigration, usually ranges from 2 to 4 months. Juvenile Chinook salmon in the Russian River emigrate as fingerlings from late February through June. Chinook salmon in the Russian River emigrate through the Wohler Pool at approximately 80 mm FL by mid April (the start of the peak emigration period), with a range over the season of 34 to 140 mm (Chase et al. 2001, 2002).

Ocean residence can be from 1 to 7 years, but most Chinook salmon return to the Russian River as 2- to 4-year-old adults. Like coho salmon, Chinook salmon die soon after spawning.

2.2.3 Species Range and Abundance

Data describing the historic range of coho salmon, steelhead, and Chinook salmon in the Russian River basin are limited. However, CDFG has compiled and reviewed salmonid presence data collected between 1920 and 2000 for streams in the Russian River watershed. Figure 2-4 is a CDFG map of the Russian River basin, showing salmonid distribution by species based on presence data from 1920 to 2000.

For salmonid populations in California coast ESUs, the present depressed condition appears to be the result of several long-standing, human-induced factors (e.g., habitat degradation, timber harvest, water diversions, and artificial propagation) that exacerbate the adverse effects of natural environmental variability from such factors as drought and poor ocean conditions. NOAA Fisheries has prepared several documents that address the factors that have led to the decline of coho salmon, steelhead, and Chinook salmon (NMFS 1995, 1996a, 1996b, 1998a, 1998b). These reports generally conclude that all of the factors identified in Section 4(a)(1) of the ESA have played a role in the decline of coho salmon, steelhead, and Chinook salmon. The destruction and modification of habitat, overutilization for recreational and/or commercial purposes, and natural and human-made factors are identified in these reports as the primary reasons for the decline of these west coast salmonids.

SCWA monitored the entire Chinook salmon run for the first time in 2000 at the Mirabel inflatable dam, and estimated a run of 1,500 Chinook salmon in 2000 and at least that many in

2001 (Chase et al. 2001, 2002). A total of 5,466 Chinook salmon adults were observed in 2002 (Chase et al. 2003).

There are no recent population estimates for coho salmon or steelhead in the Russian River. Population estimates for steelhead (1,750 to 7,000 adults) have been widely cited from McEwan and Jackson (1996), who attribute these estimates to CDFG. However, conversations between CDFG biologist Bill Cox and SCWA staff indicate that these estimates were based on professional judgment, and not on specific sampling data, studies, or research (S. White, SCWA, pers. comm. 1996).

Data describing the historic abundance of coho salmon, steelhead, and Chinook salmon in the Russian River watershed are scarce. Investigations into historic estimates of abundance reveal that there have not been any accurate fish counts or population estimates conducted for coho salmon, steelhead, or Chinook salmon in the Russian River basin. Early estimates were based largely on inconsistent angler catch data and newspaper accounts. For example, estimates of steelhead population numbers cited as CDFG 1965 in NOAA Fisheries' *Status Review of West Coast Steelhead from Washington, Idaho, Oregon, and California* (NMFS 1996a), were based on estimates by Hinton (1963), who extrapolated on estimates from Evans (1959). Hinton's methodology is described in Prolysts and Beak (1984) as follows:

"Hinton (1963) expanded estimates of adult steelhead runs in three tributaries (East Branch Russian River, Dry Creek, and Santa Rosa Creek) to the total Russian River on the basis of proportionate stream mileage and drainage area. He estimated the annual Russian River run at 50,000 fish. The above estimate of 2,000 fish at the base of the Coyote Dam [2,000 was estimated by Evans (1959) based on the rescue of 379 fish at the base of the dam] was used for the East Branch. Estimates for Dry Creek and Santa Rosa Creek were based on brief field visits made in connection with proposed developments."

The history of the derivation of steelhead population data, described above, exemplifies the lack of reliable, high-quality population data for salmonids in the Russian River basin. Table 2-7 summarizes the presence of listed salmonid species in recent years.

2.2.3.1 Coho Salmon

Coho salmon are generally considered to be less widespread and less abundant than Chinook salmon or steelhead in the Russian River basin. Coho salmon spawn and rear in tributaries to the Russian River. Emigrating smolts and adults migrating upstream use the mainstem Russian River primarily for migration to and from spawning and nursery areas in the tributaries. There are no data indicating that coho salmon spawn or rear in the mainstem.

Historic distribution of coho salmon included numerous tributaries in the lower and upper Russian River as far north as Corral Creek. Presence-absence data for coho salmon presented in the status review update (NMFS 1998b) and CDFG surveys (unpublished data) identify streams within the entire Russian River basin for which coho salmon presence has been noted since 1989 (Table 2-8). Data have been prioritized to indicate streams for which: 1) the most recent survey recorded coho salmon presence; 2) the most recent survey recorded coho salmon absence but which had an equal or greater number of surveys noting coho salmon presence; 3) the most recent and the majority of surveys recorded coho salmon absence.

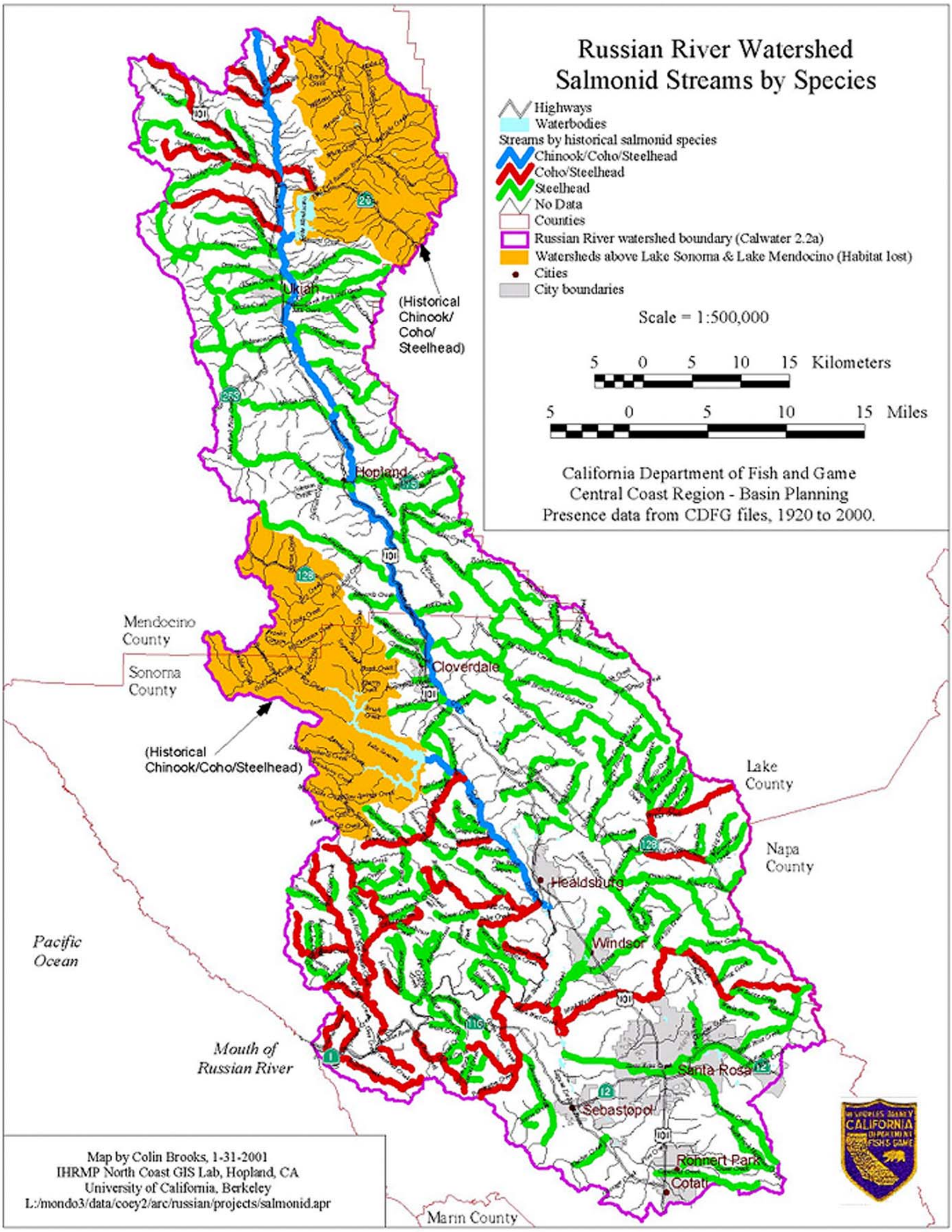


Figure 2-4 CDFG's Map of Salmonid Distribution in the Russian River Basin

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Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Alder (Mendo Co.)		X		Duncan	X	X	
Angel		X		Dutch Bill		X	
Baker's		X		Dutcher		X	
Bear		X		Duvoul		X	
Bear Canyon		X		East Austin		X	
Bearpen		X		East Fork Russian River		X	X
Bidwell		X		Eldridge		X	
Big Austin		X		Fall		X	
Big Sulphur		X	X	Felta	X	X	
Black Rock		X		Feliz			X
Blue Gum		X		Fisher	X	X	
Blue Jay		X		Forsythe	X	X	X
Blue Line		X		Franz		X	
Briggs		X		Freezeout	X	X	
Chapman Branch		X		Gibson		X	
Conshea		X		Gill		X	
Coon		X		Gill South Fork		X	
Corral	X	X		Gilliam		X	
Crane		X		Gird		X	
Crocker		X		Grape		X	
Devil		X		Gray		X	
Doolin		X		Green Valley	X	X	
Dry		X	X	Griffen (Un-named)		X	

Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries (Continued)

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Grub		X		McClure		X	
Hale		X		McDonnell		X	
Harrison		X		McDowell		X	
Hobson		X		Mercer (Un-named)		X	
Howell		X		Mill	X	X	
Hulbert		X		North Fork Mill		X	
Ingalls		X		Millington		X	
Jack Smith		X		Miller		X	
Jenner Gulch		X		Mission		X	
Johnson		X		Morrison		X	
Jonive		X		Olema		X	
Kidd		X		Orrs		X	
Laguna de Santa Rosa	X			Palmer		X	
Lancel		X		Parsons		X	
Lancel North Fork		X		Pechaco		X	
Little Briggs		X		Pena		X	
Little Sulphur		X		Peterson		X	
Lovers Gulch		X		Pole Mountain		X	
Maacama	X	X		Porter		X	
Maacama (Upper)		X		Purrington	X	X	
Mariposa	X	X		Redwood	X	X	
Mark West	X	X		Robinson		X	

Table 2-7 Presence of Listed Salmonid Species in Russian River and Tributaries (Continued)

Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present	Stream Name	Coho Salmon Present[1, 2]	Steelhead Present[2, 3]	Chinook Salmon Present
Martin		X		Rocky	X	X	
Mainstream Russian River	X	X		Squaw		X	
S.B. Robinson		X		Sturgeon		X	
Salt (Un-named)		X		Sulphur		X	
Salt Hollow		X		Thompson		X	
North Fork Salt Hollow		X		Turtle (Un-named tributary)		X	
Santa Rosa	X	X		Tyrone Gulch		X	
Sausal		X		Walker		X	
Seward		X		Wallace		X	
Sexton		X		Ward	X	X	
Sheephouse	X	X		Willow	X	X	
Sheephouse East Fork		X		Wine	X	X	
Sheephouse SW Tributary		X		York		X	
Smith		X					

1 Presence data were modified from NMFS 2001 with CDFG unpublished data.
2 Unpublished California Department of Fish and Game 2001 data from the electrofishing database for the Russian River watershed (CDFG in preparation).
3 Merritt Smith Consulting salmonid juvenile density monitoring in Sonoma County streams, synthesis of a 9-year study (1993 to 2001).

Table 2-8 Coho Salmon Presence/Absence for Russian River Tributaries since 1990

Stream Name	Present Years[1]	Years None Detected	Survey Priority[2]
Willow Creek	1990, 95	1991, 92, 93, 94, 96, 98, 2000, 01, 02	2
Sheephouse Creek	1996, 1995	1998, 2001	2
Freezeout Creek	1995	1994, 96, 2000, 01, 02	2
Ward Creek	1996	2001, 02	2
Dutch Bill Creek	2002	2001	1
Green Valley Creek	1993, 94, 95, 96, 97, 99, 00, 01, 02	1998	1
Purrington Creek	1994	2001	1
Mark West Creek	1993, 94, 95, 2001	1996, 97, 99, 2002	1
Laguna de Santa Rosa	1994		3
Santa Rosa Creek	1993, 94	1995, 2001	2
Mill Creek	1995	1996, 2001, 02	1
Wine Creek	1998	2001, 02	3
Unnamed (Turtle)[3]	1996	2001, 02	3
Maacama Creek	1993, 94, 95	1996, 97, 99	3
Redwood Creek	1993, 94, 2001	1995, 96, 97, 99, 2002	1

[1] Presence/absence data were modified from NMFS 2001b with CDFG unpublished data.
[2] First-priority streams are those streams for which the last survey recorded the presence of coho salmon at some life-history stage. Second-priority streams are those streams for which historical presence is noted, but more recent surveys did not record presence. Third-priority streams are those streams for which multiple recent surveys have not recorded the presence of coho salmon.
[3] Presence noted in an unnamed tributary.

There have been no recent efforts to quantify coho salmon populations in the Russian River, and a reliable estimate of coho salmon abundance within the basin has never been developed. Criteria used by NOAA Fisheries (NMFS 1998b) to evaluate population trends for the coho salmon status review update required a minimum of 6 years of abundance data for which sample sites and survey methods were consistent over all years. There are no streams within the Russian River basin that have 6 years of abundance data. Though limited in sample size, coho salmon data collected since 1989 indicate very small numbers of coho salmon exist within relatively isolated pockets of the Russian River. In 2001 and 2002, 32 and 28, respectively, of the historic coho salmon streams within the Russian River were sampled for juvenile coho salmon. Coho salmon were found in only three of these steams in 2001 and two streams in 2002 (CDFG unpublished data 2001a and 2002b). Genetic studies indicate populations in the Russian River basin are highly inbred (Hedgecock et al. 2003).

No coho salmon have been observed during survey efforts conducted between 1999 and 2001 on Mark West, Santa Rosa, and Millington creeks for SCWA's Russian River Basin Steelhead and Coho Salmon Monitoring Program (Pilot Study). However, CDFG reports coho salmon present in Mark West Creek in 2001 (CDFG unpublished data 2001). Green Valley Creek appears to be the only current stronghold for coho salmon. The DCFH on Dry Creek at Warm Springs Dam produced and released an average of approximately 70,000 Age 1+ coho salmon each year, from 1980 to 1998. However, no coho salmon have been produced at the hatchery since 1998

2.2.3.2 Steelhead

Historical data show that steelhead are widespread in the Russian River watershed, occupying all of the major tributaries and most of the smaller ones (Table 2-7 and Figure 2-4).

Most spawning and rearing habitat for steelhead is likely to occur in high-gradient habitats present in tributaries. During snorkel surveys conducted by SCWA in 2002, rearing steelhead were observed in the upper mainstem, mostly between Hopland and Cloverdale, but also as far south as Healdsburg (Cook 2003b). Observation of large numbers of young-of-the-year (YOY) steelhead during recent monitoring by SCWA at the Mirabel inflatable dam and Wohler Pool indicate that some spawning and juvenile rearing may occur in the lower and middle mainstem before smolt outmigration (see Section 2.2.4).

There is general agreement that the steelhead population has declined in the last 30 years (CDFG 1984, 1991), but limited quantitative data are available to support this assumption. SCWA, CDFG, and NOAA Fisheries are currently developing programs to monitor trends in salmonid populations for the basin, and recent, short-term population data are available for two streams: Santa Rosa and Mark West creeks (Cook and Manning 2002).

There has been substantial planting of hatchery-reared steelhead within the basin, which may have affected the genetic constitution of the remaining natural population. Almost all steelhead planted prior to 1980 were from out-of-basin stocks (Steiner 1996). Since 1982, stocking of hatchery-reared steelhead has been limited to progeny of fish returning to the DCFH and the CVFF.

2.2.3.3 Chinook Salmon

Historic data show Chinook salmon presence in the mainstem Russian River, the East Fork Russian River, and Dry Creek (Figure 2-4). Chinook salmon currently spawn in the mainstem upstream of Asti and in larger tributaries, including Dry Creek (Steiner 1996; B. Coey, CDFG, pers. comm. 2000a). Chinook salmon tissue samples were collected in 2000 by SCWA, CDFG, and NOAA Fisheries from the mainstem, Forsythe, Feliz, and Dry creeks. There were anecdotal reports of Chinook salmon in the Big Sulphur system.

It is uncertain whether or not naturally-spawning Chinook salmon were historically present in the Russian River (NMFS 1999c). There is little information pertaining to Chinook salmon populations prior to the completion of the PVP project in 1922. Snyder (1908) described Chinook salmon in the Russian River. Steiner (1996) reviewed historical reports for records of Chinook salmon. Cannery records from before 1890 suggest that most of the salmon harvested were too small (less than 20 pounds) to be Chinook salmon. Several reports and correspondences (Shapovalov 1946, 1947, 1955; Murphy 1945, 1947; Pintler and Johnson 1958; Fry 1979, cited in Steiner 1996) suggest there were few, if any, Chinook salmon in the river. However, recent SCWA trapping data indicate that fish size may be a poor indicator of species. Of the few (16) Chinook salmon trapped, only 10 percent were larger than 20 pounds (S. White, SCWA, pers. comm. 2003a). Other reports and communications indicate that Chinook salmon spawned in the upper portions of the river (Lee and Baker 1975), and that Chinook salmon were harvested by local tribes in Coyote Valley prior to the construction of Coyote Valley Dam (W. Jones, CDFG, pers. comm., cited in Steiner 1996).

Chinook salmon population estimates beginning in the 1960s suggest that in the past, documented returns might have been associated with periods of sustained hatchery stocking. CDFG estimates Chinook salmon escapement in 1966 was 1,000. USACE in 1982 reported an estimated escapement of only 500, despite heavy planting in Dry Creek during the 1980s. Adult returns to DCFH fell short of total escapement goals, although it is unknown what portion of the return was harvested through sport and commercial fishing. The largest adult Chinook salmon return to DCFH was 212 fish, excluding grilse (12 percent of the goal in 1988 to 1989).

Smolt emigration studies and adult counts conducted by SCWA at the Mirabel inflatable dam since 1999 provide the most reliable estimates of Chinook salmon abundance within the basin (Chase et al. 2000, 2001, 2002). The 2002 mark/recapture study estimated over 200,000 Chinook salmon smolts passed the dam from March 27 through June 8 (Chase et al. 2003). These data show that although Chinook salmon have not been stocked in recent years, natural reproduction has occurred. Furthermore, video monitoring of the fish ladders documented substantial numbers of adult Chinook salmon. The smolt emigration studies and monitoring of adult passage are described in Section 2.2.4. Distribution of Chinook salmon redds observed during a 2002 survey of the Russian River is presented in Figure 2-5. Redd surveys in 2003 found several Chinook redds in the mainstem Russian River and in Dry Creek (Cook 2004).

2.2.4 Summary of Current Salmonid Distribution and Abundance Studies

SCWA has initiated several studies in recent years to address the need for additional data describing salmonid population trends, distribution, habitat use, and abundance in the Russian River basin. Studies currently in progress include a population monitoring program designed to detect trends in salmonid populations in the basin, and a fish-sampling program designed to assess potential effects to salmonids from SCWA's inflatable dam. Studies were conducted under a Section 10(a)(1)(a) permit, issued to SCWA by NOAA Fisheries. Information from these studies specifically relevant to the status of salmonid species in the Russian River is briefly summarized in the following sections. Additional information from these studies is described where relevant in other sections of this BA.

2.2.4.1 SCWA's Population Monitoring Pilot Study – Electrofishing Surveys

SCWA has initiated a population-monitoring program designed to detect trends in salmonid populations and to identify possible fisheries management and enhancement opportunities in the watershed. The program is referred to as the Russian River Basin Steelhead and Coho Salmon Monitoring Program (Pilot Study). It began in fall 1999 with a pilot study to collect detailed information on the distribution, habitat use, and abundance of juvenile coho salmon and steelhead in streams of the Russian River basin (Cook and Manning 2002). Streams sampled include Santa Rosa, Millington, and Mark West creeks (tributaries of the Russian River). Santa Rosa and Millington creeks were sampled in 1999; all three creeks were sampled in 2000; and Santa Rosa and Millington creeks were sampled in 2001. In addition, surveys were conducted on Sheephouse Creek in 2000, and Green Valley Creek in 2001. Study methods and results are described in Cook and Manning (2002) and are summarized briefly below.

Summary of Study Methods

Fish sampling was conducted along the three study streams within selected reaches. Stream reaches were distinguished by channel type as described by Rosgen (1996).

The three channel types sampled in the study included:

B2 Channel: Streams with moderate entrenchment, moderate gradient, and aquatic habitat dominated by riffles and occasional pools.

C4 Channel: Low-gradient, meandering streams dominated by riffle and pool habitats.

F4 Channel: Low-gradient, entrenched streams with a broad bed and dominated by riffle and pool habitats.

Each channel type was divided into subreaches and habitat units for fish sampling purposes. Within each stream reach, habitat data were sorted into three general habitat types: riffle, flatwater, and pool. All study reaches included the three habitat types, except Santa Rosa Creek F4 Channel, which had only flatwater and pool habitat types.

Electrofishing was used to sample fish and consisted of a stratified random sampling method. Fish scales from a sample of captured fish were collected for age analysis. Habitat data were collected at habitat units, including maximum water depth, length, and average width.

Summary of Results

No coho salmon were observed during the electrofishing surveys, while steelhead were captured in all three study streams and in most sample units. A total of 31,795 fish were captured during the 3-year study and 6,835, or 21.5 percent, were steelhead. In general, steelhead was the predominant species in the B2 Channel headwater reaches of the three study streams.

<u>Santa Rosa Creek</u>

Where steelhead were present, the predominant age class was YOY with a few older fish present. (Population age distributions would normally have greater numbers of the youngest fish.) In 1999, the age-class composition of steelhead greater than 1 year old was 0 percent in the F4 Channel, 8 percent in the C4 Channel, and 17 percent in the B2 Channel. Similar age-class trends occurred in 2000 and 2001. These data indicate that the C4 and B2 channels provide the primary rearing and year-round habitat for steelhead, and the F4 Channel is primarily used for migration.

The population trend from 1999 to 2001 in Santa Rosa Creek varied by habitat type, but in general included a peak in 2000 with relatively lower numbers observed in 1999 and 2001. This trend was likely affected by annual rainfall.

<u>Millington Creek</u>

Millington Creek is a small headwater tributary of Santa Rosa Creek located in Mt. Hood Regional Park. Steelhead ranged from 78 to 89 percent of the total catch. Species composition along this reach consisted of native steelhead and sculpin. The population trend from 1999 to 2001 in Millington Creek included a peak in 2000 with lower numbers observed in 1999 and 2001.

<u>Mark West Creek</u>

The Mark West Creek study area included an F4 Channel reach above the confluence with Santa Rosa Creek, followed by a lower B2 Channel and C4 Channel located in the foothills, and an upper B2 Channel in the mountainous headwaters. Species composition along this reach varied from several native and non-native warmwater species in the F4 Channel lowlands with less than 1 percent steelhead, to a composition of 100 percent steelhead in the upper B2 Channel headwaters. YOY and a few fish older than 1 year were present. Because surveys were conducted during a single year, no population trends could be evaluated.

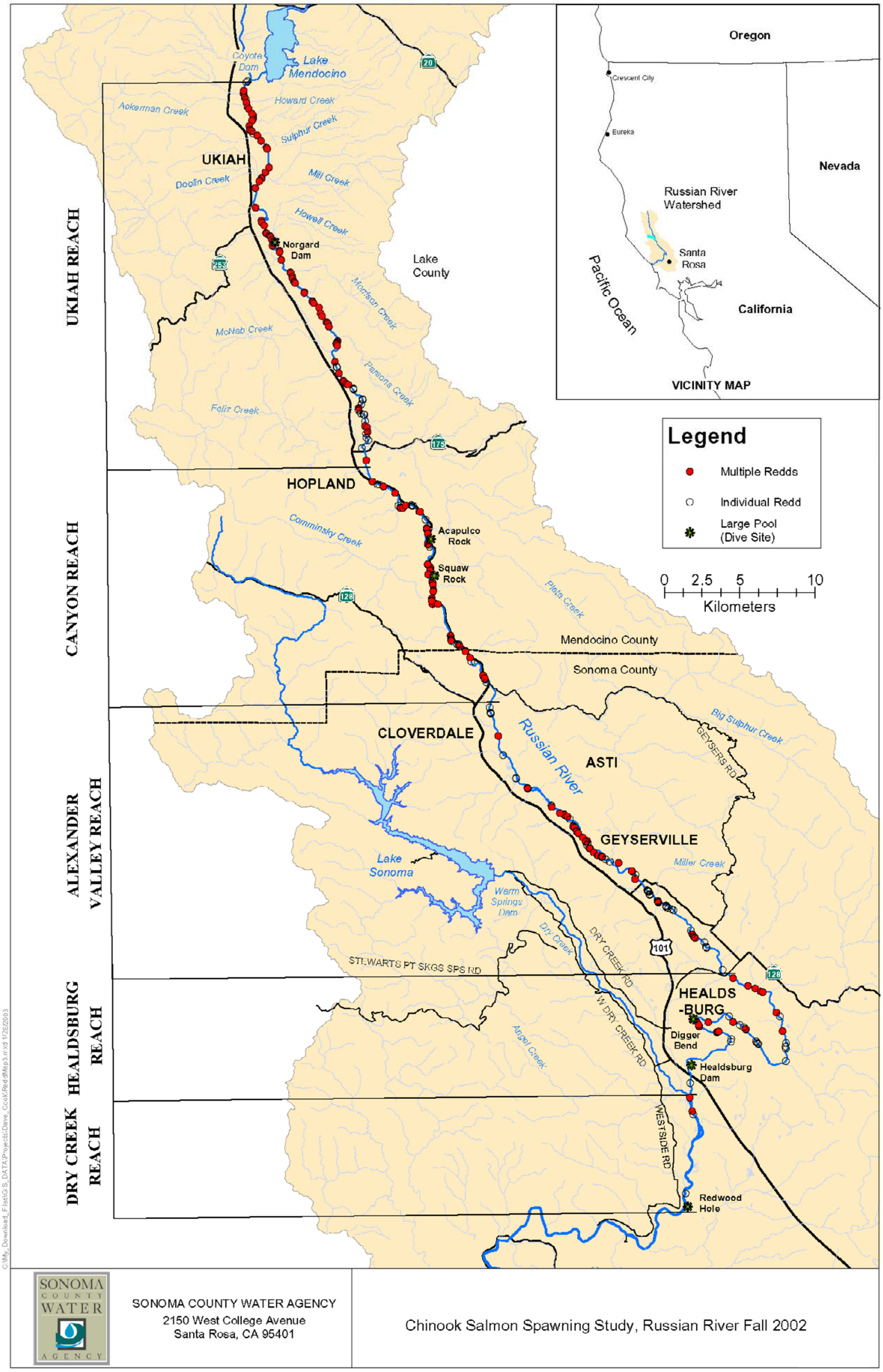

Figure 2-5 Chinook Salmon Spawning Study, Russian River

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2.2.4.2 SCWA's Population Monitoring Pilot Study – Snorkeling Surveys

In addition to the electrofishing surveys described above, snorkeling surveys are being conducted as part of the Russian River Basin Steelhead and Coho Salmon Monitoring Program. Presence-absence surveys were conducted on Sheephouse Creek in 2000, and Green Valley Creek in 2001. These creeks were selected for the study based on recent reports of coho salmon occurrences. Snorkeling survey methods and results are described in Cook and Manning (2002) and are summarized briefly below. The mainstem Russian River from Healdsburg to Ukiah was surveyed in 2002 (Cook 2003b). Snorkeling survey methods in the mainstem Russian River were different; .5-kilometer (km) reaches were surveyed by teams of three, one on each bank and one in the center, and a certain number of sites per reach of river were surveyed.

Snorkel surveys were conducted in pools with a maximum depth greater than 40 centimeters (cm) and underwater visibility at least 200 cm. On Green Valley Creek, single-pass observations were made in each pool to establish presence/absence of coho salmon or steelhead, and the number of each species observed was estimated and recorded. SCWA staff employed a two-phase survey design on Sheephouse Creek to estimate fish abundance. The two-phase survey design was developed by David Hankin from Humboldt State University Department of Fisheries and is described in Cook and Manning (2002).

Snorkeling surveys were conducted on an approximate 3.3-km-reach of Sheephouse Creek between September 27 and October 5, 2000. Surveys were conducted in 122 of 157 total pools in the study reach (78 percent). A total of 450 YOY and 195 steelhead greater than 1 year (Age 1+) were observed during the surveys. Other species observed included sculpin and suckers. No coho salmon were observed in Sheephouse Creek. The estimated population of YOY steelhead in Sheephouse Creek was 680 ± 60, based on the snorkel-survey results. It was not possible to estimate total population for the Age 1+ class of steelhead.

Snorkeling surveys were conducted on an approximate 2.5 km-reach of Green Valley Creek between August 22 and September 6, 2001. Snorkel surveys were conducted after CDFG collected 212 coho salmon from the sampling reaches for a hatchery captive broodstock program. Surveys were conducted in 43 of 98 total pools in the study reach (44 percent). A total of 230 YOY steelhead, 78 Age 1+ steelhead, and 422 YOY coho salmon were observed during the surveys. Other species observed included roach, stickleback, green sunfish, and sculpin.

Cook (2003b) examined the extent of potential rearing habitat in the mainstem of the Russian River. The study area extended 106 km along the river from Ukiah to Healdsburg and included four reaches, the Ukiah, Canyon, Alexander Valley, and Healdsburg reaches. Dive surveys were conducted in summer and fall 2002 to count fish at randomly selected river segments, and habitat characteristics were recorded. Steelhead distribution and relative abundance are presented in Figure 2-6.

Steelhead were observed in all four study reaches, but their distribution and numbers varied substantially. The distribution of steelhead was related to water temperatures. Maximum water temperatures of study reaches generally increased in a downstream direction, and data collected during dive surveys were comparable to permanent temperature stations located in the study reaches. Steelhead in the Ukiah and Canyon reaches (with survey site maximum temperatures of 22ºC and 22.5ºC, respectively) appeared "healthy and vigorous." The highest temperatures occurred in the Alexander Valley and Healdsburg reaches (25ºC and 24ºC, respectively), which may be a factor in the lower fish counts. Habitat also appeared to be a factor. Steelhead were almost exclusively found in riffle and cascade habitats, but were seldom seen in flatwater and deep pool habitats. Food transport in faster water may help steelhead to grow in relatively high water temperatures. Riffle and cascade habitats were most frequently found in the Canyon reach. Species and habitat composition are summarized in Figure 2-7.

2.2.4.3 SCWA's Inflatable Dam/Wohler Pool Fish Sampling Program

SCWA's inflatable dam/Wohler Pool Fish Sampling Program is a 5-year study designed to assess effects to salmonids associated with operation of SCWA's inflatable dam facility. The dam impounds approximately 5.1 km (3.2 miles) of river, creating a long pool (the "Wohler Pool").

A pilot study was conducted in 1999 to assist in developing the study plan for the Mirabel inflatable dam/Wohler Pool Fish Sampling Program. The sampling program was initiated in 2000. Results of fish sampling activities conducted during the pilot study (1999) and the first three sampling seasons (2000 to 2002) are summarized below.

The sampling program has several components:

- Water-temperature monitoring in Wohler Pool to evaluate the thermal regime in the pool, to determine if the impoundment results in an increase in the rate at which water warms as it passes through the Wohler Pool, and to determine if the pool becomes thermally stratified during the summer months. Characterization of the fish community in the Wohler Pool to determine species composition and to assess the relative abundance of predatory fish (on salmonids) above the inflatable dam.
- Evaluation of hatchery steelhead smolt emigration through the Wohler area using radio telemetry to determine if operation of the inflatable dam affects smolt emigration.
- Timing and relative abundance evaluation, using rotary screw traps, of Chinook salmon and steelhead smolt emigration past the inflatable dam.

Monitoring adult upstream migration to verify that anadromous fish are able to successfully ascend the existing fish ladders located at the inflatable dam. Monitoring adult upstream migration and the evaluation of the timing and relative abundance of

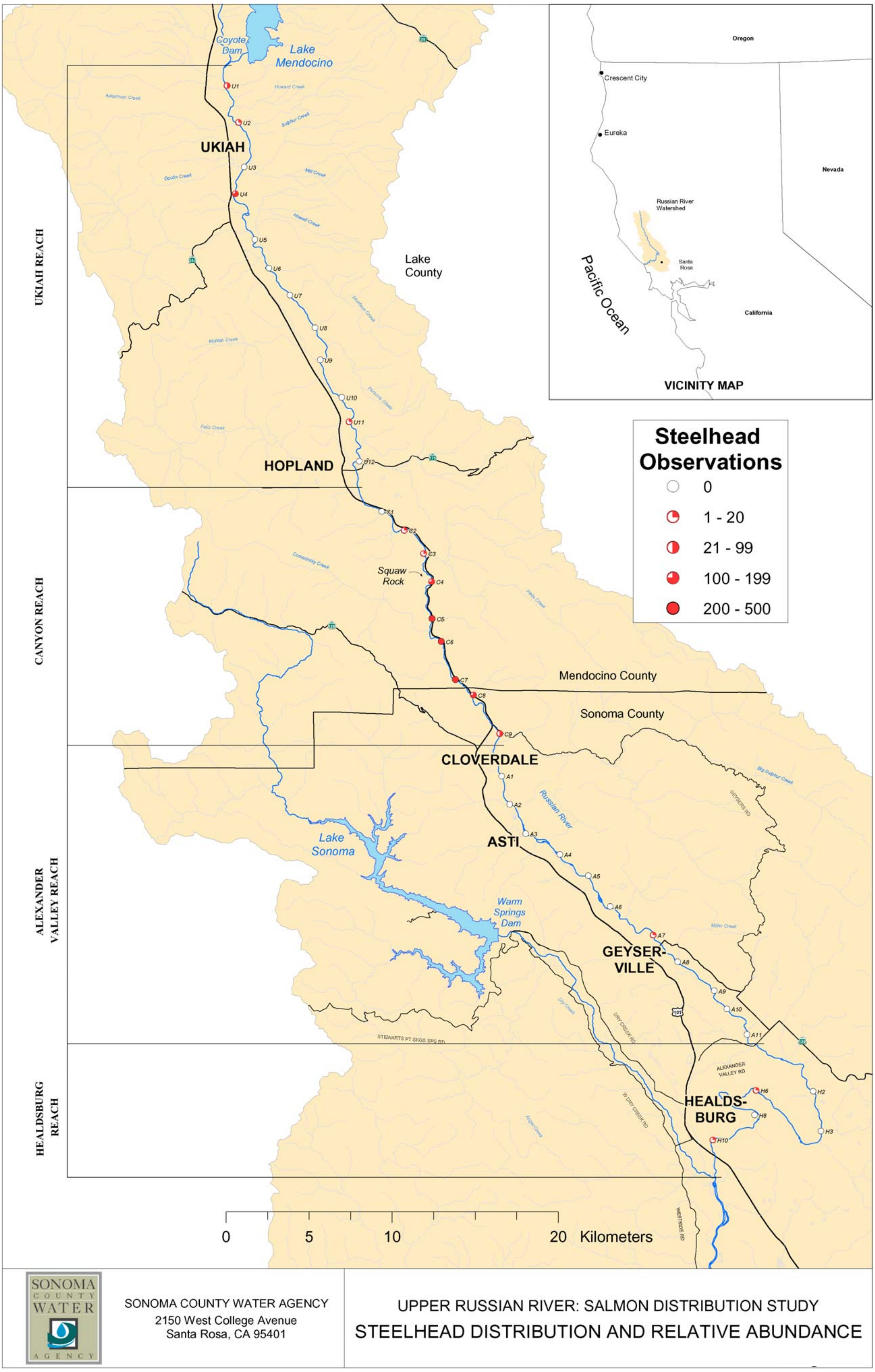

Figure 2-6 Steelhead Distribution and Relative Abundance in 2002 (Cook 2003)

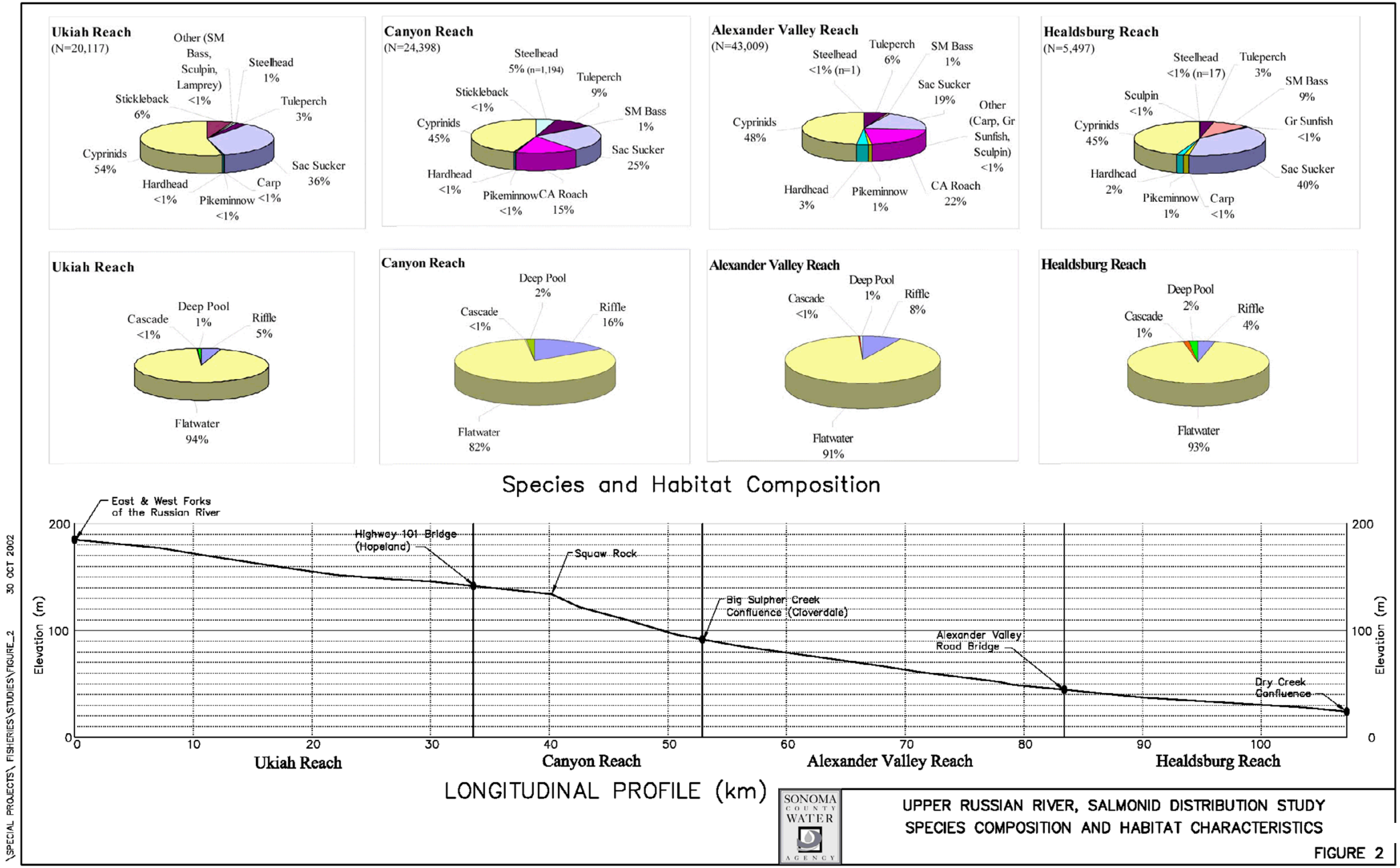

Figure 2-7 Russian River Mainstem Species Composition and Habitat Characteristics (Cook 2003)

Chinook salmon and steelhead smolt emigration provide information relevant to the status of listed fish species in the Russian River. This program is described briefly below.

Smolt Emigration

The objective of this sampling program is to collect information on wild salmonid smolts emigrating through the study reach.

Methods

A passive sampling methodology (rotary screw trap) was used to capture fish as they migrated past the trapping site (located approximately 60 meters downstream of the inflatable dam). Rotary screw fish traps are designed to capture downstream migrating juvenile fish.

Two sizes of rotary screw traps were operated during the 1999 to 2002 sampling seasons: an 8-foot-diameter trap was used prior to inflation of the dam, and one or two 5-foot-diameter traps (depending on flow conditions) were used after the dam was inflated. During the 2002 sampling season, one 8-foot-diameter trap and two 5-foot-diameter traps were operated concurrently throughout the trapping season. Table 2-9 summarizes the dates of operation of the rotary screw traps and the dates of operation of the inflatable dam for 1999 to 2002.

A mark-recapture study was conducted in 2001 and 2002 to estimate the number of Chinook salmon smolts migrating past the dam. Trapping began after the Chinook salmon run had begun in 2001; therefore, the numbers presented do not represent a seasonal total. Trapping began at the start of the emigration period in 2002, although the mark recapture phase of the study was delayed until the average size of Chinook salmon exceeded 60 mm FL.

Trapping data provided information on species composition and timing of emigration past the inflatable dam. Trapping also allowed for the collection of size and age data, and allowed for the collection of tissue for DNA sequencing. Variations in study conditions (such as the number of days of trapping and river discharge) do not allow a comparison of juvenile counts between years.

Table 2-9 Dates of Operation of Rotary Screw Trap, 1999 to 2002

1999														
April														
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
May														
1	2	3	4	5	6	7	8	9	10	11	12	13[1]	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30

One 8-foot-diameter trap in operation.

One 5-foot-diameter trap in operation.

[1] Dam inflated on May 13, 1999.

2000														
April														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
May														
1	2[1]	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
June														
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

One 8-foot-diameter trap in operation.

One 5-foot-diameter trap in operation April 25 – May 2, 2000.

Two 5-foot-diameter traps in operation May 2 – June 29, 2000.

[1] Dam inflated on May 2, 2000.

Table 2-9 Dates of Operation of Rotary Screw Trap, 1999 to 2002 (Continued)

2001														
April														
16	17	18	19	20	21	22[1]	23	24	25	26	27	28	29	30
May														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
June														
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14

Two 5-foot-diameter traps in operation between the afternoon of April 19, 2001 and June 7, 2001. Traps were not operated on April 22, May 28, or May 29 due to insufficient flows.

[1] Dam inflated on April 22, 2001.

2002														
March														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
April														
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16[1]	17	18	19	20	21	22	23	24	25	26	27	28	29
30														
May														
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
June														
31	1	2	3	4	5	6	7	8	9	10	11	12	13	14
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29

Traps installed the afternoon of February 28, 2002. One 8-foot-diameter trap and two 5-foot-diameter traps operated concurrently through April 23, 2002.

[1] Dam inflated on April 16, 2002.

Results

Results of the trapping data are presented in Table 2-10.

Table 2-10 Juvenile Salmonids Captured in the Rotary Screw Traps, 1999 to 2002

Species	1999[1]	2000[2]	2001[3]	2002[4]
Wild Steelhead – Smolts	107	134	53	250
Wild Steelhead – Young-of-the-Year	69	763	150	5,843
Wild Chinook Salmon – Smolts	193	1,361	3,722	19,319
Hatchery Steelhead – Smolts	31	68	8	1,825

1 Traps operated for 19 days between April 21 and May 29, 1999.
2 Traps operated for 81 days between April 7 and June 29, 2000.
3 Traps operated for 46 days between April 19 and June 7, 2001.
4 Traps operated between March 1 and June 27, 2002.

The number of wild smolts is substantially greater than the count of hatchery smolts in 1999 to 2001, while the number of hatchery smolts is substantially greater than the count of wild smolts in 2002. This is a reflection of the study period. In years 1999 to 2001, the study period occurred primarily after the latest (mid-April) release dates of hatchery smolts, but in 2002 the study period began on March 1 and was within the period of hatchery releases. The substantial numbers of YOY steelhead may be associated with high tributary flow conditions, which may indicate that some spawning and juvenile rearing occurs in the lower and middle mainstem (in which case survival may be low), or may indicate that steelhead fingerling migrate to rearing areas in the Estuary.

1999 Sampling Season Results and Significant Findings

During the 19 days of sampling (between April 21 and May 29, 1999), a total of 193 Chinook salmon smolts, 107 wild steelhead smolts, and 69 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). Although the data collected in 1999 were limited due to the intermittent sampling schedule, the study marked the first time that Chinook salmon smolts were captured in the river in significant numbers. The results of the 1999 sampling effort redirected the focus of the trapping study to include the collection of basic life-history data on Chinook salmon smolts in addition to assessing the effects of the dam on steelhead emigration.

2000 Sampling Season Results and Significant Findings

A total of 1,361 Chinook salmon smolts were captured between April 8 and June 28, 2000. The number of Chinook salmon smolts captured daily remained high through May and rapidly declined during the last 2 weeks of June. Although the start of the Chinook salmon smolt emigration period could not be determined from the data collected in 2000, the emigration period extended (at a very low level) through June.

A total of 134 steelhead smolts were captured throughout the 2000 trapping season.

Steelhead smolts were captured primarily in April and May, with low numbers of wild smolts captured through mid-June.

A total of 763 wild steelhead YOY were captured from April 10 through June 29, 2000. The large number of observed steelhead YOY may indicate that suitable spawning habitat is present in the mainstem Russian River in the vicinity of the inflatable dam. It is also possible that the YOY were washed out of upstream (mainstem and tributary) spawning habitat by a storm on April 16. Although comprehensive habitat surveys have not been conducted in the Wohler Pool vicinity, SCWA fisheries biologists have not observed suitable spawning substrate during monitoring activities in the Wohler Pool.

A few steelhead YOY were also captured in the Wohler Pool during August electrofishing surveys. These fish were generally larger than similar aged steelhead captured in Mark West and Santa Rosa creeks during fall surveys conducted by SCWA. The larger size suggests that some of these YOY were rearing in the mainstem river in the vicinity of the Wohler Pool. However, it is also possible that the YOY captured during boat electrofishing surveys drifted downstream from more upstream mainstem rearing habitat.

2001 Sampling Season Results and Significant Findings

In 2001, the river configuration below the dam changed, resulting in improved trapping conditions. Prior to 2001, the river channel below the dam was relatively uniform in depth across the channel with no discernable thalweg. In 2001, a small island formed in the middle of the channel, resulting in a split channel with the flows being concentrated along shorelines at both moderate and low flows. This channel configuration resulted in two well-defined thalwegs that concentrated emigrating fish and greatly improved trapping efficiencies over the previous years.

During the 46 days of sampling conducted between April 19 and June 7, 2001, 3,722 Chinook salmon smolts, 53 wild steelhead smolts, and 150 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). A mark-recapture study was conducted for Chinook salmon from May 3 through June 5, 2001. Estimates of smolt emigration past the trap ranged from 18,511 using the weekly capture efficiencies to 20,341 using the seasonal capture efficiency. During the 5-week mark-recapture study period, 2,314 Chinook salmon smolts were actually caught. The estimates presented do not represent a seasonal estimate of smolt abundance since the first part of the emigration period was not sampled.

2002 Sampling Season Results

The rotary screw traps were deployed on February 28, 2002. During the period of sampling between March 1 and June 27, 2002, a total of 19,319 wild Chinook salmon smolts, 250 wild steelhead smolts, and 5,843 wild steelhead YOY were captured in the rotary screw traps (Table 2-10). Increased numbers of salmonids captured in the screw traps in 2002 may be due in part to increased trap efficiency (one 8-foot-diameter trap and two 5-foot-diameter traps were operated concurrently throughout the trapping season), and may also be associated with yearly population variability. The large number of steelhead YOY observed in 2002 (as in 2000) suggests that steelhead spawn and rear in the mainstem Russian River.

In 2002, the beginning of the smolt emigration period was sampled for the first time. Chinook salmon smolts were first captured in the trap on March 1, 2002 (three fry averaged 38 mm FL). Numbers and size of fish slowly increased in March and April, and numbers peaked in late April/early May. A mark-recapture study was initiated on March 26. Based on recapture rates and estimated trap efficiency, 215,875 Chinook salmon smolts were estimated to have emigrated through the study area between March 26 and June 9.

Adult Upstream Migration and Juvenile Migration through Fish Ladders

The main objective of video monitoring is to verify that anadromous fish are able to ascend the Denil fish ladders that provide access past the dam. A secondary objective assessed the timing of migration and relative numbers of anadromous fish utilizing the fish ladders while the dam was inflated. Monitoring of upstream migration was conducted only while the dam was in operation.

<u>Video Monitoring Methods</u>

Two study methods were employed to evaluate fish passage through the fish ladders. Time-lapse video photography was used to document fish passage through the fish ladders, and direct (snorkel) observations were conducted in 1999 to 2001 to determine whether large numbers of salmonids were holding below the dam. Snorkel surveys were of limited use during higher flows due to poor visibility and safety concerns in the area below the dam. At lower flows, snorkel surveys were effective in verifying that significant numbers of adult fish were not holding below the dam.

Underwater video cameras were located at the top of the ladders. The cameras generally recorded the movement of adult fish through the ladders 24 hours per day throughout the time period that the dam was inflated. When the dam was deflated, the fish ladders became inoperable; thus, the cameras were pulled at that time. Table 2-11 summarizes the dates of video monitoring for 1999 to 2002. Video monitoring was continuous throughout the study period, with a few exceptions (e.g., short-term system malfunctions).

In 1999 and 2000, monitoring began in May, soon after the dam was inflated. In 2001, monitoring was initiated in August (although the dam was inflated on April 22, 2001) because results of 1999 to 2000 monitoring indicated that adult salmonids were rarely using the fish ladders prior to August. In addition, monitoring conducted in 2000 continued through early January because conditions required the dam to be in operation longer.

Table 2-11 Dates of Video Monitoring, 1999 to 2002

Study Year	Date Dam Inflated	Date Dam Deflated	Dates of Video Monitoring
1999	May 13	Nov 14	May 20 – November 16
2000	May 2	Jan 10	May 12 – January 10
2001	April 22	Nov 13	August 7 – November 13
2002	April 16	Dec 11	August 6 – December 10

Video Monitoring Results, 1999 to 2002

Operation of the dam and fish ladders generally occurs between May and November, which coincides with a portion of the Chinook salmon migration period. (Chinook salmon migrate upstream primarily from September through December.) Steelhead and coho salmon begin their upstream migrations later in the year, often after the dam is removed, and are therefore less likely to be observed during video monitoring.

Species observed entering the fish ladders included Chinook salmon, chum salmon, steelhead, Pacific lamprey, American shad, Sacramento pikeminnow, hardhead, Sacramento sucker, smallmouth bass, common carp, and white catfish. Most of the non-anadromous species were noted as “milling” in the exit boxes, as opposed to migrating upstream or downstream through the fish ladders. Detailed counts were made of anadromous fish and large cyprinids (potential predators) only. Observations of Chinook salmon and steelhead are described below. Adult coho salmon were not identified during video monitoring.

Chinook Salmon Results

Table 2-12 summarizes monthly counts of adult Chinook salmon observed migrating through the existing adult ladders at the inflatable dam during the 1999 to 2002 study seasons based on video monitoring.

Although only a fraction of the Chinook salmon migration was monitored in 1999, adult Chinook salmon were observed migrating through the fish ladders in numbers larger than previously believed to exist in the river. Chinook salmon were first observed in the fish ladder on August 26, 1999, but the majority was counted between October 27 and October 30.

In 2000, the entire Chinook salmon run was monitored for the first time. A total of 1,322 Chinook salmon were identified with an estimated run of 1,500 fish migrating above the dam. The Chinook salmon run began in early September, peaked in late November, and ended in late December.

Table 2-12 Monthly Counts[1] of Adult Chinook Salmon Observed Migrating through the Inflatable Dam Fish Passage Facilities, 1999 to 2002

Date	1999	2000	2001	2002
May	0	0	--	--
June	0	0	--	--
July	0	0	--	--
August	1	1	1	9
September	12 (3)	88 (5)	25	176
October	145 (76)	670 (63)	759 (10)	2,329
November	47 (12)	492 (51)	514 (74)	2,889
December	--	71 (37)	--	63
January	--	0	--	--
Totals	**205 (91)**	**1,322 (156)**	**1,299 (84)**	**5,466 (9)**

[1] Numbers in parentheses are salmonids that could not be positively identified, but based on timing and percentages of fish that were identified, were likely Chinook salmon.

A partial run count of 1,299 adult Chinook salmon through November 13, 2001, which may have occurred prior to the peak of the run, suggests the 2001 run may have been higher. Fish were still being counted when the dam was deflated, indicating that the run continued beyond the study period.

Between August 8 and December 10, 2002, a total of 5,466 adult Chinook salmon were observed. Substantial numbers of Chinook salmon were observed in early October, but the largest peak numbers occurred in early November.

Average daily water temperatures during the 2000 Chinook salmon migration ranged from 20.4°C on August 24 (date the first Chinook salmon was observed in the fish ladder) to 9.8°C during mid-November. The temperature on September 7 (the date that the run essentially began at the dam) was 19.5°C, and temperatures exceeded 20.0°C for 7 consecutive days in mid-September. Thirty-six Chinook salmon were observed in the fish ladder during this period. The weekly average water temperature was 14.7°C during the peak of the Chinook salmon migration period (last week of October).

Adult Steelhead Results

Winter-run adult steelhead migrate to their spawning grounds from November through June, typically peaking between December and March. The dam is seldom inflated during much of this time period; as a result, most of the steelhead spawning migration occurs outside of the sampling period. The number of steelhead recorded in the fish ladders represents only those fish migrating when the dam was inflated, and cannot be used as an estimate of steelhead abundance. Steelhead were divided into three categories: wild fish (possessing an adipose fin), hatchery fish (adipose fin clearly clipped), and unknown origin (could not be clearly determined if the adipose fin was clipped or not).

Adult steelhead were not observed in the fish ladders during the 1999 or 2001 sampling seasons. A total of 532 adult steelhead were observed in the fish ladders between May 15, 2000 and January 10, 2001 (consisting of 110 wild steelhead, 252 hatchery steelhead, and 170 steelhead of unknown origin). Adult steelhead were observed in the fish ladder in every month that the cameras were operated, except August and September. The run of wild adult steelhead above the dam was completed prior to the installation of the video cameras on May 6, 2000. After this date, four adult steelhead were identified as being wild. The numbers of steelhead identified in the ladders slowly increased during November, with relatively large numbers of steelhead migrating through the fish ladder beginning in December.

Steelhead were observed migrating upstream through the fish ladders at streamflows similar to those discussed for Chinook salmon. Adult steelhead were observed in the fish ladders when average daily temperatures exceeded 20.0°C on several occasions during the spring and early summer, with one fish ascending the ladder when the average daily temperature exceeded 24°C. However, water temperatures during mid-November when the upstream migration began in earnest ranged from approximately 10.0°C to 12.0°C.

<u>Juvenile Steelhead Results</u>

Wild and hatchery smolts, and smolts of undetermined origin, were observed passing through the fish ladder throughout the study. In addition, several steelhead smolts were observed entering the exit boxes, "milling," and leaving the box in the same direction from which they originally entered. Since it was possible that at least some of the observations were the same fish passing upstream and downstream repeatedly through the boxes, it was not possible to estimate the number of fish moving past the dam during any study year. However, observation of juvenile steelhead indicates that at least a few juvenile steelhead inhabit the Russian River in the vicinity of the Mirabel inflatable dam throughout the summer.

2.2.5 Genetic Variance in Coho Salmon, Steelhead, and Chinook Salmon

A key feature of the ESU concept is conservation of genetic resources that represent the evolutionary legacy of a biological species (Waples 1996). The ESA mandates the restoration of listed species in their natural habitats to a level at which they can sustain themselves without further legal protection, so NOAA Fisheries focuses on protecting naturally-spawning populations. The ESA recognizes that conservation of listed species may be facilitated by artificial means (Hard et al. 1992). Information on the genetic variance within and between naturally and artificially spawned populations is used to develop recovery programs and assess their effects on conservation of genetic resources within the Russian River basin.

Early work based on protein electrophoresis has formed an important basis for identification of salmon and trout population structure for management and conservation. Protein electrophoresis detects variation (allozymes) for a portion of the genome, the one that codes functional proteins.

Much of the recent genetic data are based on DNA analysis. Analysis of nuclear DNA (e.g., microsatellite DNA) detects differences at a more fundamental level—the nucleotide sequence—and therefore may potentially resolve smaller genetic differences between populations and individuals. Only minute amounts of tissue are needed for microsatellite (or mitochondrial [mtDNA]) analysis and this enables the use of nonlethal sampling methods on endangered and threatened fish. Alleles are different forms of a gene at a single gene locus. For example, a gene in an individual may contain one allele that codes for blue eyes and one for brown eyes. Allelic differences are used to measure genetic variation.

Genetic differences accumulate between populations that are strongly reproductively isolated from each other because gene flow is substantially reduced. Mutation and random genetic drift in isolated populations cause genetic differences to accumulate. These differences are used to measure the relative degree of reproductive isolation between populations (genetic distance) and to create phylogenetic trees that illustrate the relationships between populations and groups of populations. These genetic relationships can be compared to geographic distances to see if they are correlated. Fish are more likely to stray (resulting in gene flow between populations) between streams that are geographically closer to each other. Alternatively, out-of-basin stock transfers may reduce genetic differences between populations, but disrupt beneficial local adaptations that have a genetic basis. The relative amounts of genetic diversity within (F_{IS}) and between (F_{ST}) populations, which can affect the ability of a species to persist over the long term, can be quantified.

This section summarizes information on the genetic variance of coho salmon, steelhead, and Chinook salmon.

2.2.5.1 Coho Salmon

NOAA Fisheries (NMFS 1995) examined the genetic relationships of California and southern Oregon coho salmon populations by combining allozyme data from NOAA Fisheries samples with data from Olin (1984) and Gall et al. (1992). Two major geographic clusters were apparent and separated by a relatively large genetic distance (D = 0.126[2]). The northern, primarily large river group (within the Southern Oregon/Northern California Coast ESU directly to the north), included samples from the Elk River (near Cape Blanco) to the Eel River (just north of Cape Mendocino). The southern, primarily small river group, included nine samples from Fort Bragg to Tomales Bay (Lagunitas Creek), as well as three samples from north of Cape Mendocino. Considerable genetic diversity among populations was apparent within both groups.

The Willow Creek sample from the Russian River clustered with the Huckleberry Creek sample from the South Fork Eel River, but not with other creeks in the Eel River, which were more closely related to rivers to the north. Willow Creek clustered loosely with other proximate streams such as Lagunitas, Navarro, or Russian Gulch.

The Bodega Marine Laboratory (BML) used nuclear DNA to document coho salmon population diversity within the CCC ESU, with a special emphasis on the Russian River

[2]Cavalli-Sforza and Edwards (1967) Chord distance (D) was used.

basin (Hedgecock et al. 2003). Low numbers of spawners in the Russian River watershed have resulted in extensive reliance on the sampling of juveniles, so molecular markers were developed to distinguish coho salmon from Chinook salmon and steelhead.

The BML study generally supported the California ESU structure, which includes the CCC, the South of San Francisco ESU recognized by California's ESA, and the Eel and Mattole River samples from the Southern Oregon/Northern California ESU. However, even after the genetic tree was adjusted for admixture and family structure, the node separating the South of San Francisco ESU and a large proportion of the CCC ESU was not supported. Green Valley Creek in the Russian River watershed and Redwood Creek in Marin County were outliers in the genetic tree.

Russian River Basin Samples

Coho salmon from the Russian River watershed and from streams in Marin County were collected for the Russian River coho salmon captive broodstock program. Results of the BML study and of genetic research at the NOAA Fisheries South West Science Center, Santa Cruz Laboratory (NOAA Fisheries Santa Cruz Laboratory) are being used to assess the genetic diversity of these populations and to identify suitable source populations for the captive broodstock program.

Juvenile samples from Green Valley Creek from 1997, 1998, and 2000 were assessed for their level of inbreeding and compared to samples from hatchery populations and from other watersheds within the ESU (Hedgecock et al. 2003). The Green Valley 1998 samples had high levels of inbreeding. The effective number of breeders in this tributary was estimated as 10, which suggests this population has undergone a population bottleneck and may be subject to a substantial amount of genetic drift. The study concluded the risk of inbreeding in the coho salmon captive broodstock program would be high if Green Valley Creek fish were used or were not interbred with populations from a neighboring watershed (such as Lagunitas or Olema creeks). The Green Valley samples were also very different from Russian River hatchery samples. The homogeneity of samples from Lagunitas Creek (in Marin County) from different year classes and tributaries was found to contrast with the heterogeneity of samples in other drainages. Stocking history, which could influence the relationships between populations, was not researched for Lagunitas Creek.

Samples from Green Valley Creek were distant from other populations. The samples collected in 2002, which were the most distant, were very different from Lagunitas (F_{ST} values[3] of 0.101 to 0.109) and Olema (F_{ST} 0.132 to 0.134), suggesting that there could be a substantial risk of outbreeding depression if these populations were interbred. (Outbreeding depression is the phenomenon of decreased fitness following hybridization of individuals from populations with divergent genetic composition, which can occur when out-of-basin stocks are used in a hatchery program. Coadapted gene complexes may be disrupted or local adaptations can be lost.) Additional samples evaluated by the

[3]F statistics (Wright 1931, 1943) measure the average genetic correlations between populations. An F_{ST}=1.0 between two populations indicates very divergent populations.

NOAA Fisheries Santa Cruz Laboratory showed that Green Valley fish collected for the captive broodstock program were closely related to fish collected from two other watersheds in the Russian River (Mark West and Maaccama creeks). This indicates that a unique Russian River basin stock that is not closely related to the Lagunitas and Olema creek populations or to coho salmon stocked in the past by the DCFH, may currently exist (Garza and Gilbert-Horvath 2003). A large number of alleles present in Russian River populations but not in Lagunitas populations suggest that the Russian River populations may have local adaptations. Interbreeding of the two populations could cause significant outbreeding depression and therefore was not recommended (Garza and Gilbert Horvath 2003).

The NOAA Fisheries Santa Cruz Laboratory is undertaking a comprehensive genetic assessment of population structure and demography for coastal populations of coho salmon in central California, and will develop baseline genetic information for use in future monitoring and propagation efforts. The research project is designed to evaluate and document differences between the genetic composition of wild fish and artificially introduced fish. The laboratory is analyzing tissue samples from coho salmon collected for the captive broodstock program at DCFH to develop a mating scheme. These data are being used to evaluate the relative risks between inbreeding and outbreeding depression as the capture, mating, and release protocols are developed for the captive broodstock program.

2.2.5.2 Steelhead

Allozyme studies presented in Busby et al. (1996) show a great deal of genetic variability among populations of this ESU. Samples from Coleman National Fish Hatchery and two tributaries in the Sacramento River Basin cluster distinctly from other steelhead in this ESU. Another cluster includes streams from this ESU (Lagunitas, Scott, San Lorenzo, Alameda, Arroyo Hondo, and Gaviota) but also includes the Ten Mile River sample in Mendocino County north of the Russian River, and Whale Rock near San Luis Obispo in southern California. An anomalous geographic structure was detected in this allozyme study. Though modest differences were found between samples from Ten Mile River and Lagunitas Creek, these samples were also found to be more similar to the Whale Rock Hatchery (near San Luis Obispo) samples than to populations geographically closer (Scott Creek and San Lorenzo). Nielsen (1994) found substantial differences in frequencies of some mtDNA alleles between Mendocino and Marin County samples, but the Ten Mile River and Lagunitas Creek allozyme data did not reflect this, as seen by their relative similarity.

Nielsen (1994) included Russian River samples in a study that found biogeographic distribution of mitochondrial and nuclear DNA in naturally-spawning coastal steelhead in California. Data for both mtDNA and a single microsatellite locus (Omy77) gave significant differentiation between three broad bioregions: north coast, central coast (Russian River to Point Sur), and south coast. Six steelhead hatchery populations (Van Arsdale Hatchery on the Eel River, Van Duzen River Hatchery, DCFH on the Russian River, Big Creek Hatchery near Scott Creek, San Lorenzo River hatchery in Santa Cruz, and Whale Rock Hatchery near Morro Bay in southern California) did not show significant biogeographic structuring of mtDNA genotypes, but were dominated by mtDNA types that were most common in their general geographic area. Similarly, no significant biogeographic association with Omy77 was detected.

In a study that compared hatchery stocks and geographically proximate populations of anadromous salmonids, hatchery stocks of steelhead carried significantly more mtDNA types than geographically proximate wild populations (Table 2-13) (Nielsen 1994). The authors suggest that the abundance of these rare mtDNA types in hatchery stocks may be due to historic stock transfers that introduced divergent lineages into hatchery stocks.

Table 2-13 The Number of *O. mykiss* mtDNA Types Found Only in Wild or Hatchery Populations in Paired Comparisons of Geographically Proximate Populations, Based on Fish Sampled from 1990 to 1993 (Nielsen, Gan, and Thomas 1994)

Location	Number of mtDNA Types	
	Wild Only	**Hatchery Only**
Eel River	0	3
Russian River	1	2
Big Creek Hatchery	0	3
Whale Rock Hatchery	1	2
Total	**2**	**10**

The NOAA Fisheries Santa Cruz Laboratory is conducting further analysis of the genetic structure of coastal populations of steelhead. A study is also underway to compare steelhead populations upstream and downstream of ten impassable barriers in the Russian River, and to conduct a phylogenetic analysis within the Russian River watershed (Deiner et al. 2002). Preliminary review of data from populations above and below a passage barrier on Mill Creek found differences between the populations and found unique alleles in the population above the barrier.

2.2.5.3 Chinook Salmon

As discussed in Section 2.2.3.3, the size of the historical Chinook salmon population in the Russian River is unknown. Current monitoring programs such as data from the inflatable dam monitoring program have documented a naturally-spawning population in recent years, despite the suspension of hatchery production in 1999 (Chase et al. 2001, 2002, 2003). Given the high level of interbasin transfers over many years, and that the sources of many of the Chinook salmon planted were streams in what are now considered separate ESUs, naturally-spawning Chinook salmon within the river may represent a genetic conglomerate of many stocks. Data, however, are unavailable to quantify the degree of introgression. Similarly, adults used as broodstock may themselves be descendants of many stocks. Historically, substantial stocking of Sacramento River

Chinook salmon into the Russian River has occurred and could have contributed to the current genetic stock structure. Klamath River stocks have also been introduced.

Out-of-basin stocks were planted in the Russian River through 1998. Historically, a large percentage of Chinook salmon planted in the Russian River were from the Sacramento River (38 percent). Several runs of Chinook salmon are found in the Sacramento and San Joaquin rivers (in the California Central Valley ESUs), including spring-, fall-, and late fall-run. The Central Valley historically contained predominantly spring-run fish, but fall-run are currently the most numerous.

Coastal Chinook Salmon Differentiation

Coastal Chinook salmon populations south of Cape Blanco, Oregon, are substantially different morphologically and physiologically from populations to the north. Moreover, there is finer scale differentiation between shorter coastal systems and the two larger river basins, the Rogue and Klamath rivers (Myers et al. 1998).

In a recent study in the Chinook salmon status review (Myers et al. 1998), allelic frequencies for 29 to 31 loci collected over 15 years by researchers at NOAA Fisheries, University of California at Davis, Washington Department of Fish and Wildlife (WDFW), and the Alaska Department of Fish and Game (ADFG) were pooled. A total of 193 populations from Alaska to California were analyzed. A clear separation of populations with ocean-type and stream-type life-histories was found. Several distinct subclusters appear among ocean-type samples, including: 1) the British Columbia and Puget Sound rivers, 2) coastal rivers of Washington, Oregon, and California, 3) Upper Klamath River samples, 4) the Columbia River basin, and 5) the Sacramento-San Joaquin River drainage.

The population structure suggested in this status review (Myers et al. 1998) is mostly consistent with previous studies. A California coastal group comprising populations south of the Klamath River, were consistent with Bartley and Gall (1990) and Bartley et al. (1992, cited in Myers et al. 1998). Sacramento-San Joaquin River populations were distinct, and DNA data indicated that winter-, spring-, fall-, and late fall-runs were genetically distinct (Hedgecock et al. 1995; Banks et al. 1996; and Nielsen 1995, 1997).

In addition to the Sacramento River, the Klamath River has been historically a source of Chinook salmon plants into the Russian River (11 percent). Banks et al. (1999) used five microsatellite loci to look at population structure for 11 fall- and spring-run Chinook salmon samples in the Klamath River and compared these samples to Chinook salmon in the Central Valley. Two large clusters in the Klamath River basin populations differed from Central Valley populations. The upstream-most populations in the Klamath River basin (Scott River, Shasta River, and Iron Gate Hatchery) were differentiated from subclusters of fall- and spring-run subclusters in the Trinity and Salmon rivers. The Blue Creek population (from the lower Klamath River) was more similar to southern Oregon and California coastal Chinook salmon populations than to upper Klamath/Trinity River populations.

Additional genetic data analyzed for a Chinook salmon status review update (Busby et al. 1999) helped delineate the California Coastal Chinook ESU (NMFS 1999c). In 1998 and 1999, NOAA Fisheries, CDFG, USFWS, and the U.S. Forest Service collected samples from adult Chinook salmon from 13 rivers and hatcheries in the Central Valley and Klamath River basin, and analyzed them along with allozyme data for California and southern Oregon Chinook salmon used in Myers et al. (1998). The population structure in this analysis was consistent with the major genetic groups found in previous studies (Utter et al. 1989; Gall et al. 1992; Myers et al. 1998, cited in NMFS 1999c). The Central Valley group was the most divergent. The remaining samples formed two large groups that included samples from the Klamath River basin and from coastal rivers. Blue Creek clustered with the coastal samples. The coastal river samples contained two subclusters from rivers south and north of the Klamath River. The genetic distances between these two subclusters corresponded roughly to the differences found between Central Valley spring-, fall-, and late fall-run Chinook ESUs, and the Washington and Oregon coast Chinook ESUs.

MtDNA haplotypes from some fall-run Chinook salmon smolts captured in 1993 and 1994 from the Russian River Estuary did not match haplotypes from the DCFH, and a rare haplotype was found only in Chinook salmon from the Russian and Guadalupe rivers (Nielsen 1994, cited in Busby et al. 1999). Significant haplotype frequency differences between Guadalupe River Chinook salmon and the four spawning runs in the Central Valley were primarily due to the rare haplotype found in two fish in the Guadalupe River but not found in the Central Valley. (The remaining 27 samples from the Guadalupe River were indistinguishable from the Merced River and Feather River hatchery samples.) However, when samples from the Sacramento River drainage and the Guadalupe River from 1991 to 1995 were analyzed, one fish from the 1994 fall-run Coleman Hatchery carried a haplotype previously found only in the 1994 collection from the Guadalupe River, suggesting this stock may be the source of the unique Chinook salmon haplotypes found in the Guadalupe River in 1993 to 1994 (Nielsen 1997).

Genetic studies to date suggest that coastal stocks within the California Coastal Chinook ESU are distinct from stocks in neighboring ESUs. Rare mtDNA haploytypes found in the Russian and the Guadalupe rivers (in separate ESUs) may have been the result of hatchery strays.

Genetic samples collected from naturally produced Chinook salmon juveniles in the Russian River by SCWA in 1999 have been analyzed by the BML to assess their affinity with other coastal Chinook salmon populations (Hedgecock et al. 2003). Samples from Chinook salmon in the Russian River (collected from Forsythe Creek and the inflatable dam area where Chinook salmon migrate through) were compared with samples from the Eel, Klamath, and Trinity rivers, DCFH (two sample sets derived from Eel River stocks), Central Valley, and Santa Clara Valley. No correction for family structure was necessary because samples did not have high levels of linkage disequilibrium. Chinook salmon in the Santa Clara Valley and Central Valley stocks (inland stocks) were closely related. Based on seven loci, coastal Chinook salmon from the Eel, Russian, and Klamath rivers clustered on one side of the dendogram while the inland populations clustered on the other side of the dendogram, which indicates they are genetically different. The Eel and

Russian rivers cluster together, but are distinct from one another with a bootstrap value of 919,[4] which indicates they are genetically distinct. These data indicate Chinook salmon from the Russian River were not closely related to Central Valley or Eel River populations. The report concluded that Chinook salmon in the Russian River belong to a diverse set of coastal Chinook salmon populations.

2.2.6 Salmonid Predators

Figure 2-6 shows the species composition found during snorkel surveys conducted in the Russian River mainstem in summer and fall of 2002 (Cook 2003b). Cyprinids and Sacramento suckers dominated most of the observed fish communities. Juvenile cyprinids (California roach, pikeminnow, and hardhead) can be difficult to distinguish and were identified to family when species identification was not possible. Although population estimates are not available, these surveys show that native and non-native species that could potentially compete with or prey upon juvenile salmonids were present throughout the watershed.

Data collected in 2000, 2001, and 2002 during electrofishing sampling (as part of SCWA's inflatable dam/Wohler Pool Fish Sampling Program) indicated that three potential salmonid predators inhabit the Russian River near the inflatable dam: Sacramento pikeminnow, smallmouth bass, and largemouth bass (Chase et al. 2001). Two large striped bass have been captured in 4 years of sampling, and two others have been observed during video monitoring and snorkel surveys, although, in general, not many have been seen. Adults of each of these species may prey upon juvenile salmonids. However, electrofishing sampling data from 1999 through 2002 indicate that the pikeminnow, smallmouth bass, and largemouth bass populations in the vicinity of the inflatable dam are composed predominantly of juveniles. For example, in 2000, 40 percent (1,349) of all fish captured during SCWA's inflatable dam/Wohler Pool Fish Sampling Program fell in the predatory category. Eighty-five percent (1,148) of the predators captured were YOY, and only 2.6 percent (35) of the predators were Age 2+ or older (i.e., large enough to prey on juvenile salmonids). Results from SCWA's 1999 sampling showed a similar predominance of juvenile fish (Chase et al. 2000).

The following sections briefly describe the life-history, habitat, and occurrence of each of these potential predatory species in the Russian River.

2.2.6.1 Sacramento Pikeminnow

The Sacramento pikeminnow is native to the Russian River (Moyle 2002). Site-specific information on pikeminnow in the Russian River is limited, and most of what is known their biology and life-history comes from studies conducted in other river systems, primarily in the Sacramento and San Joaquin rivers. This species occupies pools throughout the Russian River and the lower reaches of larger tributaries (Chase et al.

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[4]The significance of nodes in a phylogenetic tree is tested with bootstrap analysis, in which genetic distance is estimated by producing many trees (1,000 in this study). A node is considered significant if it is recovered in more than half of the bootstrap trees (500).

2001). However, estimates of pikeminnow abundance in the Russian River are not available. Sacramento pikeminnow was observed in low numbers (2.8 percent of the total captures) during SCWA electrofishing surveys conducted in August 2000 in the Wohler Pool area.

Pikeminnow prefer warmwater streams with abundant pools (Taft and Murphy 1950; Moyle and Nichols 1973). Pikeminnow generally prefer relatively low-velocity habitat (< 15 centimeters per second [cm/s]) except when foraging or moving from one pool to another, moderate depths (0.5 to 2.0 meters), and a substrate of gravel to boulder (Knight 1985).

Pikeminnow juveniles feed on aquatic insects, and, as they grow, switch to a diet primarily of fish (Moyle 2002). Adult Sacramento pikeminnow are known to eat salmon and steelhead smolts (Moyle 2002). Pikeminnow generally begin to include fish in their diet after reaching a length of 165 to 230 mm. A literature review conducted by SCWA staff found three size classes of pikeminnow in terms of the potential to prey on salmonids: pikeminnow that are less than 200 mm FL (where fish are an insignificant part of their diet); those between 200 and 300 mm FL (where fish comprise a small portion of their diet); and those greater than 300 mm FL (where fish comprise a significant part of their diet) (Chase et al. 2001).

2.2.6.2 Smallmouth Bass

Smallmouth bass are an introduced species and are widespread and abundant in the lower Russian River. Smallmouth bass appear to be widespread throughout the mainstem Russian River with peak abundances reportedly occurring in the Alexander Valley (Chase et al. 2001, Cook 2003a). Smallmouth bass was the most abundant species observed during SCWA electrofishing surveys conducted in August 2000 in the Wohler Pool, comprising 34.4 percent of the total captures (Chase et al. 2001).

Edwards et al. (1983) describe optimal habitat for smallmouth bass as cool, clear streams with abundant shade and cover. Smallmouth bass prefer deep, dark hiding areas with cover provided by boulders, stumps, rootwads, and large woody debris. Optimal water temperatures for growth range from 26 to 29°C, and preferred temperatures range from 21 to 27°C (data cited by Edwards et al. 1983; Carlander 1977). Growth reportedly does not occur at temperatures below 10°C to 14°C (data cited by Edwards et al. 1983; Carlander 1977).

Smallmouth bass will consume a wide variety of food items, including fish, crayfish, insects, and amphibians (Moyle 1976). Smallmouth bass have been documented to feed on salmonids, primarily under-yearling Chinook salmon smolts such as those found in the Russian River. Zimmerman (1999) developed a linear regression for the size of salmonids that could be consumed by smallmouth bass between 200 and 400 mm FL. Based on this regression, a 200-mm smallmouth bass can consume a 100 mm salmonid. Smallmouth bass observed during SCWA electrofishing surveys ranged in size from 50 to 370 mm FL.

2.2.6.3 Largemouth Bass

Little data are available on the abundance and distribution of largemouth bass (an introduced species) in the Russian River. They are apparently confined to the lower sections of the river, but are generally not considered abundant. Largemouth bass were captured in low numbers (approximately 1 percent of the total captures) during SCWA's sampling in the Wohler Pool (Chase et al. 2001), but were not captured during a similar study conducted in 1999 (Chase et al. 2000). They were not observed during snorkel surveys in 2002 (Cook 2003a).

In rivers, largemouth bass prefer low-velocity habitats with aquatic vegetation (Stuber et al. 1982; Carlander 1977). Stuber et al. (1982) reviewed the literature on largemouth bass and concluded that optimal temperatures for growth of juvenile and adult largemouth bass range from 24°C to 36°C.

Largemouth bass feed primarily on fish and crayfish after reaching a size of 100 to 125 mm standard length (SL) (approximately 125 to 150 mm FL). The risk of largemouth bass predation on salmonids is low because their habitats seldom overlap. However, salmonids may become vulnerable to largemouth bass predation during the later half of the emigration period when streamflows decrease and water temperatures increase. Under these conditions, largemouth bass are more likely to become active. Largemouth bass will apparently consume any animal that it can fit in its mouth, including small mammals, waterfowl, frogs, and fish.

This section describes USACE and SCWA activities and operations under baseline conditions. The environmental baseline provides the foundation for developing proposed changes in operations to benefit listed fish species in the Russian River watershed, which are described in Section 4.0. Project actions implemented since the MOU was signed in 1997, as well as current actions that would be continued, are part of the proposed project (see Section 4.0). The potential effects of these actions on listed species will be evaluated in Section 5.0.

The effects of the activities and operations under baseline conditions were evaluated in detail in *Interim Reports 1* through *8* (ENTRIX, Inc. 2000a, 2000b, 2001d, 2001a, 2001b, 2001c, 2002b; FishPro and ENTRIX, Inc. 2000). These reports are available on USACE's web site (http://www.spn.usace.army.mil/ets/rrsection7). Results of these analyses are included in the descriptions of the activities and operations. Section 3.8 integrates these factors to identify the project activities affecting listed fish species in the Russian River Watershed.

3.1 COYOTE VALLEY DAM AND LAKE MENDOCINO

Three major reservoir projects provide water supply storage for the Russian River watershed: Lake Pillsbury on the Eel River, Lake Mendocino, and Lake Sonoma. SCWA must make water supply releases from Lake Sonoma and Lake Mendocino in accordance with criteria established in 1986 by D1610 (SWRCB 1986b). Flow regulation under D1610 is described in detail in Section 3.3. Releases from Lake Pillsbury are discussed in Section 2.1.

Lake Mendocino is a multi-purpose reservoir that provides flood protection to areas below Coyote Valley Dam; supplies water for domestic, municipal, industrial, and agricultural uses; and supports hydroelectric power generation. Lake Mendocino is the major component of USACE's Coyote Valley Dam (see Figure 2-1 in Section 2.1). It controls runoff from a drainage area of approximately 105 square miles and also stores water diverted by PG&E into the Russian River basin via the PVP.

Coyote Valley Dam is a rolled earth embankment dam with a crest elevation of 784 feet above mean sea level (MSL), which is 160 feet above the original streambed. Lake Mendocino, which began storing water in 1959, had an original design capacity of 122,500 AF at the spillway crest elevation of 764.8 feet above MSL. A bathymetric (water-depth) study in 1985 (SCWA and USGS 1985) indicated that the storage capacity was 118,900 AF, which is 3,500 AF less than its original capacity. A more recent bathymetric survey conducted in 2001 indicated that the current storage capacity is 116,500 AF (P. Pugner, USACE, pers. comm., 2003).

3.1.1 LAKE MENDOCINO

Lake Mendocino has distinct pools for water supply and flood control, determined by the season and elevation of the water surface. The total water supply pool capacity shared by SCWA and MCRRFCD in Lake Mendocino was originally 72,300 AF, but has been reduced by sedimentation to approximately 69,000 AF (USACE 2001). The capacity above 69,000 AF is used for flood control. SCWA and the MCRRFCD share state water-rights permits to store up to 122,500 AFY in the reservoir. SCWA determines releases to be made from the water supply pool. However, when the water level rises above the top of the water supply pool (seasonally between elevation [El.] 737.5 feet and El. 748 feet above MSL) and into the flood control pool, USACE determines releases. USACE also determines releases during inspections and during maintenance and repair of the project.

The elevation of the top of the water supply pool in Lake Mendocino changes in the fall and spring months. Approximately 20,000 AF of additional water can be stored for water supply in the flood control pool toward the end of the rainy season (March to April) as the need for flood control storage decreases. USACE decides whether this additional water storage capacity becomes available in March or April. The maximum summer pool level is held at 748.0 feet beginning as early as March 31 through October 12. In October, when the need for flood control storage increases again, the reservoir level must be reduced to its winter level. October 13 through October 31, the required flood space increases uniformly until it reaches the full flood space reservation requirement for the winter at pool elevation 737.5 feet (68,400 AF), where it remains until March 31. If the USACE determines that the flood control functions of the project will not be impaired (e.g., under *dry* water supply conditions), reductions to the flood control space could occur as early as March 1.

The operation of Coyote Valley Dam has altered year-round mainstem flow patterns. Dam operations reduce discharge peaks, prolong winter high flows, and increase summer flows above Healdsburg to an average of 200 cfs (Steiner 1996). During the rainy season (October through May), natural streamflow (rather than reservoir releases) accounts for most of the flow of the Russian River. During the dry season (generally June through September, although it may be a longer period), the natural flow in the Russian River downstream of Coyote Valley Dam is augmented by water released from Lake Mendocino.

Winter operations primarily involve storing water in the dedicated flood control pool while releases are made for flood control. When possible, releases from Coyote Valley Dam are controlled so that flow at Hopland, approximately 14 miles downstream, does not exceed the 8,000-cfs channel-capacity of the mainstem. This is sometimes not possible when inflow to the lake is very high or when uncontrolled flows in the mainstem Russian River exceed 8,000 cfs.

Coyote Valley Dam has a minor effect on winter flood flows at Healdsburg because it regulates only 13 percent of the watershed above Healdsburg (and only 7 percent of the entire watershed) (USACE 1986b). USACE's 1986 study evaluated the effect of Coyote Valley Dam on the flood of 1964. The results indicated that operation of the dam reduced the flood peak by 29 percent at Hopland, 14 miles downstream; 21 percent at Cloverdale, 30 miles downstream; 11 percent at Healdsburg, 58 miles downstream; and 7 percent at Guerneville, 74 miles downstream.

Releases from the Coyote Valley Dam water supply pool are determined by SCWA, subject to the requirements of D1610. During the summer months, SCWA releases water from Lake Mendocino to meet water supply demands between Lake Mendocino and Healdsburg, and to meet the required minimum flow at Healdsburg. In general, SCWA does not make discretionary releases from Lake Mendocino for diversions by SCWA or any other diverters below Dry Creek. Releases from Lake Mendocino are made from an outlet tunnel 128 feet below the dam spillway crest elevation at the bottom of the reservoir. This means the coolest water in the reservoir is released during summer months, until low water levels result in a loss of thermal stratification and depletion of the cold water pool (which often occurs by September).

3.1.2 Flood Control Operations of Coyote Valley Dam

USACE's main objective for flood control releases from Lake Mendocino is to prevent flood flows on the East Fork Russian River from contributing to overbank flood stages on the Russian River below Coyote Valley Dam, to the extent possible. The specific criteria for flood control operations are described in the Water Control Manual for Coyote Valley Dam (Coyote Valley Dam Water Control Manual) (USACE 1998b). The general criteria for releases from the flood control pool call for successively increasing releases in three stages as reservoir levels rise toward the emergency spillway. The Hopland streamflow gage, 14 miles downstream of Coyote Valley Dam, is the most downstream monitoring point for decisions affecting flood control releases from Lake Mendocino.

USACE limits releases from Lake Mendocino to prevent local flooding at Hopland that generally occurs when flows exceed 8,000 cfs. Because bank sloughing is likely to occur when flows decrease too rapidly, USACE has imposed a maximum ramp down rate of 1,000 cfs per hour for Lake Mendocino.

USACE has developed modified guidelines for the rates at which releases from Warm Springs Dam and Coyote Valley Dam may be changed during flood control operations. The existing Water Control Manuals allow releases to be changed at up to 1,000 cfs per hour when outflows from the reservoir exceed 1,000 cfs. To protect spawning gravel and juvenile salmonids within the Russian River and Dry Creek, USACE has developed interim guidelines in consultation with NOAA Fisheries and CDFG for release changes (USACE 1998b), as summarized in Table 3-1.

Table 3-1 Ramping Rates when Flows in Mainstem Russian River Exceed 1,000 cfs

Reservoir Outflow	Ramping Rates
0-250 cfs	125 cfs/hour
250-1,000 cfs	250 cfs/hour
>1,000 cfs	1,000 cfs/hour

USACE follows the existing guidelines 90 percent of the time (P. Pugner, USACE, pers. comm., 2000). Ramping rates from 1,000 to 250 cfs/h typically occur in winter or spring as flood control operations reduce flows from much higher rates following storm events. Typically, flows in the mainstem Russian River at Ukiah exceed 1,000 cfs when flows are reduced at these rates. Ramping rates of 125 cfs/h, or less, have been used during the low-flow summer months when maintenance or inspection of Warm Springs Dam or Coyote Valley Dam requires a reduction in releases from the water supply pool.

More specific directions are included in Exhibit A of the Coyote Valley Dam water control manual, entitled "Standing Instructions to Damtenders" (Coyote Valley Dam Standing Instructions). Operation for flood control is described by the Flood Control Diagram summarized in Exhibit A:

> *Flood Control Schedules 1, 2 and 3 releases are used to empty the flood control space following a storm. Under these schedules, releases will be limited to: (1) the discharge that does not cause the flow at the Russian River near Hopland to exceed 8,000 cfs, and (2) the discharge that results in flow at Hopland being less than that reached during the previous storm or storm series. The previous storm or storm series is defined as the events, which caused the highest pool at Lake Mendocino. In addition, releases will be limited to (1) at least 2,000 cfs and up to a maximum of 4,000 cfs if the reservoir pool did not reach elevation 746.0 feet, (2) up to a maximum of 4,000 cfs if the highest reservoir pool reached was between elevation 746.0 feet and 755.0 feet, and (3) up to a maximum of 6,400 cfs if the pool exceeded elevation 755.0 feet. Releases will not be increased or decreased at a rate greater than 1,000 cfs per hour. Schedules 1, 2, and 3 are used if no significant rainfall is predicted.*
>
> *When the QPF[1] is 1 inch or more for the next 24 hours or 2 inches or more for any 6-hour period in the next 24 hours, outflow from the lake should be limited to 2,000 cfs or less to the extent possible, so that the release can be reduced to 25 cfs within 1-1/2 hours if necessary (includes 2 hours to travel to control tower and make first gate change). Also, when the flow in the Russian River at Ukiah exceeds 2,500 cfs and is rising, releases from Lake Mendocino will be reduced to 25 cfs, insofar as possible.*
>
> *Outlet gates may be used when the pool is above the spillway crest (elevation 764.8) for Flood Control Schedule 3 releases, however the sum of the spill and the releases must not exceed 6,400 cfs, subject to the above limitations.*
>
> *The Emergency Release Schedule is used when the pool elevation is above 771.0 feet. Continue to follow the Emergency Release Schedule if the pool*

[1]The Local AWIPS MOS Program (LAMP) quantitative precipitation forecast (QPF) model produces 1- to 22-hour forecasts of precipitation over the conterminous United States.

> *elevation is between 771.0 feet to 773.0 feet. At elevation 773 feet and above, the flood control gates are fully open. The flood control gates will remain fully open until the lake has receded below elevation 773 feet. If the pool is receding and is between elevation 773.0 feet and 771.0 feet, follow the Emergency Release Schedule. Flood Control Schedule 3 releases are made when the lake has receded below elevation 771.0 feet.*

Inflows to Lake Mendocino were historically measured directly at the USGS gaging station on the East Fork Russian River, just upstream of Lake Mendocino. This station (USGS Station No. 11461500) measures the runoff from 92 of the 105 square miles of drainage area that contributes to runoff to Lake Mendocino. The USGS no longer maintains flow records for the station, but continues to collect stage data. Inflow to Lake Mendocino is currently computed from change in storage and releases.

Discharge capacity from the reservoir, with all gates open, is 5,950 cfs when the water surface elevation is at the bottom of the flood control pool (i.e., when the water surface elevation [WSE] reaches the stage when the reservoir is converted from water supply operation to flood control operation), and 6,700 cfs at full pool. Releases above this level would require use of the spillway. The design discharge capacity of the spillway is 35,800 cfs.

3.1.2.1 Previous ESA Actions on Coyote Valley Dam Flood Control Operations

To assure the safety, structural integrity, and operational adequacy of these projects, the dams are inspected periodically. Routine inspections include annual pre-flood inspections and more comprehensive 5-year periodic inspections; however, inspections and evaluations may be more frequent, if necessary. Non-routine inspections include post-earthquake inspections. For safety reasons, releases must be reduced or terminated during some portions of these inspections. Normal releases may also be reduced or modified for special testing, such as an outlet works vibration testing carried out in 1998 at Warm Springs Dam. Following formal notification by USACE to NOAA Fisheries, SCWA notifies involved regulatory agencies, including FERC and SWRCB.

USACE has entered into separate formal and informal consultations with NOAA Fisheries since 1997 to address the effects on coho salmon, Chinook salmon, and steelhead resulting from temporary flow reductions or increases from Coyote Valley Dam and Warm Springs Dam. In some cases, monitoring was conducted during the time work was scheduled to assess the potential for stranding fry and juvenile salmonids (see Section 3.1.5.2).

The temporary flow reductions and related actions conducted under previous ESA consultations are summarized as follows:

1. In July 1998, USACE submitted a BA to NOAA Fisheries to address the effects of flow reductions during periodic inspections at Coyote Valley Dam and Warm Springs Dam (USACE 1998a). On September 4, 1998, NOAA Fisheries issued a BO and incidental take statement for these activities (NMFS 1998b).

2. In May 1999, USACE submitted a BA to NOAA Fisheries to address the effects of flow reductions during pre-flood inspections at Coyote Valley Dam and Warm Springs Dam (USACE 1999a). In June 1999, NOAA Fisheries issued a BO and incidental take statement for these activities (NMFS 1999d).

3. USACE consulted with NMFS on March 17, 2000, for inspection of the outlet tunnel at Coyote Valley Dam as part of the 2000 pre-flood inspections.

   After consultation with NMFS, USACE conducted pre-flood inspections at Coyote Valley Dam on May 11, 2000. NMFS determined that the flow reduction was not likely to adversely affect federally-listed species or habitat. The terms of concurrence required ramping down in 50 cfs/hr increments. NMFS and USACE monitoring teams found that, during the ramping-down period, gravel bars became dewatered at the confluence of Ackerman Creek and the Russian River, as well as locations upstream. Stranding and mortality occurred. Since USACE did not have an incidental take statement, NMFS requested that normal operations resume. USACE immediately restored normal outflows.

   On September 22, 2000, USACE received a letter of not likely to adversely affect federally listed species or habitat for the Coyote Valley Dam reductions in flow.

4. On May 16, 2000, project operators reported abnormal noise from service gate #3 while making gate changes at Coyote Valley Dam. Flows were routed from gate #3 to gate #2 to alleviate the problem. A visual inspection of gate #3 was unsuccessful in determining the cause of the problem, requiring further investigation.

   In July 2000, USACE consulted with NMFS to reschedule the Coyote Valley Dam outlet conduit inspection and gate testing for Coyote Valley Dam.

   On October 11, 2000, USACE received a BO from NMFS for the Coyote Valley Dam inspection and gate testing.

   On October 12, 2000, after inspection of outlet conduit, USACE performed a series of tests on slide gate #3, requiring ramping up to 750 cfs to replicate the conditions under which the noises were first noted. No stranding or mortality occurred downstream.

5. On July 24, 2001, USACE consulted with NMFS for pre-flood inspection of the outlet conduit and City of Ukiah repairs to the bifurcation plate in the plenum chamber.

   On September 20, 2001, USACE received a BO from NMFS for the Coyote Valley Dam inspection and City of Ukiah work.

   On September 25, 2001, releases were stopped for 2 hours while USACE inspected the outlet tunnel. Concurrent with the USACE inspection, the City of Ukiah installed a temporary 2-foot inflatable dam within the conduit to allow the

City to work in the tunnel while releases of up to 150 cfs were made over the subsequent 4 days. Once the City's work was completed, releases were dropped to 50 cfs for 1 hour to remove the temporary dam. However, the City was not able to remove the steel plates used to keep the skirt portion of the temporary inflatable dam in place while there was appreciable flow in the tunnel. The City notified USACE of the problems encountered, and it was determined that the City would remove the steel plates during the 2002 pre-flood inspection. No mortality occurred downstream.

6. August 22, 2002, USACE consulted with NMFS for pre-flood inspection of the outlet conduit. Additionally, during the inspection, the City of Ukiah would remove the steel plates left in place from the 2001 repairs.

   On September 25, 2002, USACE received a BO from NMFS for the Coyote Valley Dam inspection.

   On September 26, 2002, releases were stopped for 2 hours while USACE inspected the outlet tunnel and the City removed the steel plates in the plenum floor. No mortality occurred downstream.

Tunnel inspections for periodic inspections in 2003 occurred on September 17 at Coyote Valley Dam, with structural inspections conducted the previous day.

3.1.3 Water Supply Operations

During water supply operations, water is released from Lake Mendocino to meet water supply demands between Lake Mendocino and Healdsburg and the required minimum flow at Healdsburg. Ordinarily, no water is released from Lake Mendocino for diversion by SCWA or any other diverters below Dry Creek. Under current demand, during a normal summer, SCWA must release close to, and occasionally exceed, 300 cfs from Lake Mendocino to allow for water supply demands above Healdsburg and still meet the 185-cfs minimum currently required by D1610 at Healdsburg. During the summer months, flow targets should be at least 10 cfs to 20 cfs above the minimum flows at Healdsburg to ensure that instream flow requirements are met regardless of fluctuating demands. Because a change in release at Lake Mendocino may take 3 days to appear at Healdsburg, changes in demand must be anticipated several days in advance.

3.1.4 Lake Mendocino Hydroelectric Power Plant

The Lake Mendocino Hydroelectric Power Plant (LMHPP), owned and operated by the City of Ukiah was completed in May 1986 at a total cost of approximately $22 million. The power plant was added as an external facility to the downstream base of Coyote Valley Dam, which was not originally designed to supply a hydroelectric plant (City of Ukiah 1981). The power plant has a total generation capacity of 3.5 MW through two generators rated at 1 MW and 2.5 MW, respectively. The City of Ukiah operates the project under a 50-year license issued April 1, 1982, by FERC (Project No. 2481-001). The City of Ukiah is a member of the Northern California Power Authority (NCPA).

NCPA owns and operates various power generation plants throughout California and provides power to their members. The City of Ukiah uses the LMHPP to supplement other power sources within the City's system and has no contractual minimum power output requirements to maintain. Power output is determined by the amount of water released from the dam for water supply, minimum instream flow requirements, and flood control, rather than power generation needs.

The hydraulic turbines require flows between 175 and 400 cfs to operate and produce electrical power. Flows below 175 cfs are not sufficient to produce power. Dam flows, which pass through the facility, are maintained at a minimum of 25 cfs.

Water flows are directed through the LMHPP from an outlet tunnel from the dam. The 959-foot-long, 12.5-foot-diameter concrete tunnel extends beneath the dam between its upstream and downstream sides. Flows exiting the facility run through a riprapped channel that merges with the East Fork Russian River approximately 700 feet downstream from the LMHPP.

The City of Ukiah has an agreement with FERC that is endorsed by CDFG and USFWS to provide between 7 and 15 cfs of water to operate the Coyote Valley Fish at Coyote Valley Dam (FERC 1983). Minimum flow rates were specified for the hatchery facility in accordance with D1610. FERC permit guidelines require the City of Ukiah to maintain DO levels downstream of the LMHPP at 7.5 mg/l at least 90 percent of the time, with a minimum requirement of 7 mg/l and a monthly median value of 10 mg/l for the year (FERC 1982). The City of Ukiah continuously monitors the DO level on a computer system. When the LMHPP turbines are in operation and the DO level approaches 7 mg/l, the turbines are shut down and the flow is diverted to the bypass valves.

Flow releases are not made for the City of Ukiah's hydroelectric plant. The plant generates power using releases made by either the USACE, for flood control purposes, or by SCWA for minimum flow releases. However, flow releases must be halted to initiate or cease hydroelectric operations. To initiate or cease hydroelectric operations, the City of Ukiah must make a request to USACE to decrease releases from the dam to 0 cfs for several hours. Halting flow releases has the potential to adversely affect listed fish in the East Fork and in the Russian River below the Forks. The lifestages affected and the severity of the effects would depend on the timing of the flow cessations.

The City of Ukiah is not currently operating the LMHPP. The City of Ukiah will develop an alternative transition procedure to eliminate the need to halt flow releases or will undergo a separate Section 7 consultation with NOAA Fisheries to address these concerns. The City of Ukiah intends to bring the power plant back into operation as soon as possible. When in operation, the LMHPP produced an annual average of 8 to 9 million kilowatt-hours of power.

3.1.5 FACTORS AFFECTING SPECIES ENVIRONMENT DUE TO OPERATIONS AT COYOTE VALLEY DAM AND LAKE MENDOCINO

3.1.5.1 Flood Control Operations

The change in hydrologic regime associated with flow regulation by dams can initiate a geomorphic response in the channel (Collier, Webb, and Schmidt 1996). The type and magnitude of adjustments depend on initial channel conditions and the extent of changes in discharge and sediment supply (Reiser and Ramey 1985). The effect of dams on the river morphology tends to diminish downstream due to discharge and sediment contributions from tributaries. Although the rate of channel change in response to flow regulation by dams is highly variable, most channel adjustments likely take place within a few decades following dam construction (Mount 1995).

Channel geomorphic changes may occur due to interruption of the sediment transport regime by dams and reservoirs. Sediments that are deposited within a reservoir will likely remove a significant portion of the total sediment load. Therefore, replenishment of sediments downstream will be reduced until there are sufficient sources of sediment input from downstream tributaries (Grant, Schmidt, and Lewis 2003). This can lead to excess stream power immediately downstream of a dam. Relatively clear water with little sediment in transport can perform more work scouring sediments from the streambed, banks, and floodplain. Thus, sediment entrainment below the reservoir may continue. Without sediment replenishment and with excess stream power, only the coarsest material may be left behind, leading to armoring of the channel bed (Mount 1995).

Adequate flows are periodically needed to maintain channel geomorphic conditions by mobilizing the streambed and transporting sediments (Trush, McBain, and Leopold 2000). Such flows are necessary to provide suitable spawning and rearing conditions for salmonids, and to flush fine sediments from the streambed and maintain bar-pool morphology. However, if flood releases are of sufficient magnitude and frequency to regularly scour redds, spawning may be adversely affected. Ideally, a balance, or dynamic equilibrium, occurs between periodic mobilization of the streambed, recruitment and transport of sediment, and sediment deposition and stability of spawning gravels. Lack of peak flows can reduce spawning gravel quality, impairing spawning success, as can an increase in the frequency and magnitude of peak flows.

On the mainstem Russian River, potential effects due to flood control operations under baseline conditions were evaluated in *Interim Report 1* (ENTRIX, Inc. 2000a). Because coho salmon do not spawn in the mainstem, effects were evaluated for steelhead and Chinook salmon only. The upper and middle reaches, between Ukiah and Alexander Valley, were included in the assessment since flood control operations at Coyote Valley Dam have little influence on the magnitude of high flows downstream of Alexander Valley.

The evaluation indicated that steelhead spawning gravels are very stable in the upper mainstem reach. The potential for scour of Chinook salmon gravels is moderate, but represents an acceptable balance between periodic streambed mobilization and spawning gravel stability. Frequent mobilization of the streambed (by bankfull discharges occurring, on average, every 1 to 2 years) and large floods (exceeding the 3- to 5-year annual maximum) are important attributes of adjustable channels that are needed to maintain a balanced sediment budget over the long-term (McBain and Trush 1997). The lower incidence of scour of steelhead gravels compared with Chinook salmon gravels is partially due to the later steelhead incubation period. The occurrence of flows in the Upper Reach that might scour spawning gravels later in the season when steelhead are incubating is fairly low.

In the Middle Reach of the Russian River at Alexander Valley, spawning gravels are less stable and subject to slightly more frequent scour than in the Upper Reach. The evaluation indicates moderately stable conditions for Chinook salmon, and slightly less stable conditions for steelhead. Higher discharges due to tributary flow accretion might account for the greater incidence of scour in the Middle Reach compared with the Upper Reach. Flood control operations do not have a significant effect on peak flows and spawning gravel scour in the Middle Reach (see Section 3.1.1 for discussion of Coyote Valley Dam effect on peak flows).

The potential for bank erosion was evaluated for the upper and middle reaches of the Russian River in *Interim Report 1* (ENTRIX, Inc. 2000a). On the mainstem Russian River, 6,000 cfs at Hopland in the Upper Reach and 8,000 cfs at Cloverdale in the Middle Reach were identified as the flow thresholds at which bank erosion is likely to begin. These flow thresholds for erosion are based on a comparison of unregulated flood recurrence intervals with Dry Creek. On Dry Creek, reported observations of bank erosion indicate that high flows greater than 2,500 cfs, which correspond to the 1.1-year average 1-day unregulated flood event, initiate erosion. There are no specific flow thresholds for which bank erosion has been observed or reported on the Russian River. Therefore, similar to Dry Creek, it was assumed that the 1.1-year flood event would be the threshold at which bank erosion is initiated. For the unregulated Russian River, the 1.1-year 1-day flood interval was determined to be 6,000 cfs at Hopland and 8,000 cfs at Cloverdale.

The analysis indicates that prolonged flows above these thresholds are relatively infrequent. At Hopland, flows never exceeded 6,000 cfs for more than 3 days in any given year (i.e., occurred less than 1 percent of the time) for each of 20 years analyzed over the 36-year period-of-record, and the risk of bank erosion in those years is relatively low. Over an additional 6 years, flows did not exceed 6,000 cfs for more than 7 days in each year (i.e., less than 2 percent of the time in any given year). There were 3 years in which flows did not exceed 6,000 cfs for more than 11 days per year (i.e., less than 3 percent of the time in any given year), which results in a moderate risk of bank erosion. There were 7 years (19 percent) in which flows exceed 6,000 cfs for 12 or more days, resulting in a high risk of bank erosion.

At Cloverdale, flows never exceeded 8,000 cfs for more than 3 days in any given year (i.e., occurred less than 1 percent of the time) for each of the 18 years analyzed over the 36-year period-of-record. Over an additional 7 years, flows did not exceed 6,000 cfs for more than 7 days in each year (i.e., less than 2 percent of the time in any given year).

There were 2 years in which flows did not exceed 6,000 cfs for more than 11 days per year (i.e., less than 3 percent of the time in any given year), and there is consequently a moderate risk of bank erosion in those years. There were 9 years (25 percent) in which flows exceed 6,000 cfs for 12 or more days, resulting in a high risk of bank erosion.

On many of the days when flows exceeded the erosion threshold at either location, discharge from Coyote Valley Dam was low. This is because flood control operations are timed so that reservoir outflows are a relatively insignificant contributor to the total flow during most runoff events to minimize flooding. This is a basic function of flood control reservoirs. Review of the runoff record indicates that, for 78 out of 91 days in the 36-year period analyzed, Coyote Valley Dam operations did not contribute to the flows exceeding the bank erosion threshold at Hopland. There were 87 days out of a total 97 days in the 36-year period of record analyzed when Coyote Valley Dam did not contribute to exceeding the bank erosion threshold at Cloverdale. This indicates that flows exceeding the erosion threshold are most often due to natural runoff conditions, rather than the timing of releases from Coyote Valley Dam. This also indicates that flood control operations at Coyote Valley Dam do not cause prolonged flows above the threshold that initiate streambank instability and erosion.

Flood control operations have a minimal effect on channel maintenance/morphologic conditions on the mainstem. The channel-forming discharge was identified by calculating the 1.5-year annual, 1-day maximum flood in the Upper Reach as 9,500 cfs at Hopland, and in the Middle Reach as 14,000 cfs at Cloverdale and 21,000 cfs at Healdsburg. *Interim Report 1* evaluated flood control operations (ENTRIX, Inc. 2000a). The evaluation indicated that the natural channel maintenance occurs only slightly less often than the estimated expected frequency of one event every 2 out of 3 years (Dunne and Leopold 1978).

On the mainstem Russian River, effects of flow ramping during flood control operations were evaluated from approximately 3 to 5 miles below Coyote Valley Dam, using hydrologic modeling at four cross sections in this reach (no cross sections are available closer than 3 miles from the dam) (ENTRIX, Inc. 2000a). A stage-change of 0.16 feet per hour (ft/hr) or less was used as a conservative criterion for protection of juvenile fish.

At Coyote Valley Dam, the results of hydraulic modeling indicate that all of the four cross sections in the upper Russian River exceed the 0.16 ft/hr and the 0.32 ft/hr criterion at 250 cfs/hr ramping rates (ENTRIX, Inc. 2001d). Change in stage was generally 0.5 ft/hr or more when ramping at 250-cfs/hr increments. However, Coyote Valley Dam is usually operated within the 250 cfs/hr interim ramping rate only when reservoir outflows are 1,000 to 250 cfs. Under these conditions, the risk of stranding due to dewatering is lower. The forks usually have considerable flow from the mainstem Russian River to attenuate ramping effects. Often flows are greater than 2,500 cfs at the forks during flood operations ramp-down, and there is a backwater effect on the East Fork which would attenuate stage-changes (P. Pugner, USACE, pers. comm., 2000). Results were similar for stage-changes associated with 125-cfs/hr flow reductions when reservoir release flows were 250 to 0 cfs. Therefore, ramping rates associated with flood control operations provide adequate protection to listed fish species.

3.1.5.2 Dam Maintenance and Inspection

During Coyote Valley Dam maintenance and inspections, flows are typically ramped down at a rate of 50 cfs per hour until releases cease. Recent historical effects of ramping on the East Fork and mainstem Russian River were evaluated regarding incidences of stranding. Based on this evaluation, the 50 cfs per hour ramping rate does not provide adequate protection from stranding for fry or juveniles of steelhead or Chinook salmon. (Coho salmon do not rear in the Upper Reach of the mainstem Russian River and were not evaluated.)

Coyote Valley Dam inspections and maintenance during September 1998 resulted in dewatering stream segments in the East Fork and farther downstream on the mainstem, creating the need to rescue juvenile steelhead. However, during inspection and maintenance in June 1999, no stranding was documented and fish rescue was unnecessary, as pools were maintained on the East Fork to provide refuge (T. Marks, USACE, pers. comm., 2000). Gage records indicate that flow downstream of the forks near Ukiah on the mainstem was at least 14 cfs during the inspection and maintenance activities. The presence of pools and lack of stranding may have been partially due to the maintenance of instream flows on the East Fork that was derived from dewatering of the stilling basin. The stilling basin provided approximately 1 to 4 cfs to the East Fork for several hours following cessation of releases from the dam. However, flow accretion from seepage or groundwater contributions are also responsible for maintaining pools and minimal streamflow on the East Fork. Over the past 6 years, approximately 5 to 6 cfs has been measured at the weir below Coyote Valley Dam during maintenance inspections after flow releases have ceased (USACE 2003a). This 5-to 6-cfs flow is assumed to be derived from either seepage around the dam or from groundwater contribution to the East Fork. No mortalities have been recorded when inspection and maintenance activities have been scheduled to take place in the late summer/fall season (September) over the past 5 years (USACE 2003a).

3.2 WARM SPRINGS DAM AND LAKE SONOMA

3.2.1 LAKE SONOMA

Lake Sonoma is a multipurpose reservoir. It provides flood protection to areas downstream; provides water for domestic, municipal, and industrial uses; and is operated for hydroelectric power production (see Figure 2-1). Lake Sonoma collects runoff from a drainage of approximately 130 square miles.

Lake Sonoma has a gross capacity of 381,000 AF at the spillway crest elevation of 495 feet above MSL. Lake Sonoma has a 130,000-AF flood control storage capacity, which is sufficient to collect runoff from a 100-year, 6-day flood event. The conservation pool has a 245,000-AF design capacity. SCWA has a water rights permit authorizing storage of 245,000-AF of water in Lake Sonoma. As with Lake Mendocino, SCWA determines the water release rate from the water supply pool in Lake Sonoma in accordance with its state water rights permits. USACE determines releases when the water level rises above the top of the water supply pool (El. 451.1 feet above MSL) and into the flood control pool.

USACE determines releases during inspections, maintenance, and repairs scheduled outside the flood control season. Following formal USACE notification, SCWA notifies affected regulatory agencies, including FERC and SWRCB, of these lower releases. USACE notifies and consults with NOAA Fisheries.

The Warm Springs Dam and Lake Sonoma Project are operated using the *Warm Springs Dam and Lake Sonoma, Dry Creek, California Water Control Manual* (USACE 1984). Objectives described in this document include: (1) provide the maximum reduction in peak-flood discharges on Dry Creek and the Russian River below Healdsburg; (2) provide the maximum practical amount of conservation storage without impairment to other project functions; and (3) maintain a minimum pool elevation of 292 feet above MSL to assure operation of the fish hatchery. The 130,000 AF of flood control storage in Lake Sonoma was designed to provide control of a flood the size of the December 1955 flood event, which had a peak discharge of approximately 26,000 cfs at the dam site and represents about a 20-year flood event.

USACE requires that a minimum fishery pool be maintained in Lake Sonoma at an elevation of 292 feet above MSL (USACE 1998b). At this minimum pool, the reservoir has a storage volume of 20,000 AF, a surface area of 415 acres, extends approximately 5 miles up Dry Creek and 2 miles up Warm Springs Creek, and has 17 miles of shoreline (USACE 1998b).

Water supply releases from Lake Sonoma are used to meet minimum instream flows and municipal, domestic, and industrial demands in the lower Russian River area and portions of Sonoma and Marin counties (USACE 1998b). To meet these demands, water released from Lake Sonoma combines with releases from Coyote Valley Dam and runoff from other tributaries. Inflow to Lake Sonoma approaches 0 from July through September, and the reservoir normally reaches its lowest level in November.

3.2.2 Flood Control Operations of Warm Springs Dam

USACE's primary objective for flood control operation at Warm Springs Dam is to reduce peak flood discharges in Dry Creek and the Russian River below Healdsburg to the extent possible. Because of the long travel time for water flow between Coyote Valley Dam and the Russian River/Dry Creek confluence, flood control operations at Warm Springs Dam are generally independent of the Coyote Valley Dam operation; however, operations of the two facilities are coordinated to avoid downstream flooding.

The criteria for flood control operation of Lake Sonoma are similar to those for Lake Mendocino, and are described in the Warm Springs Dam Water Control Manual (USACE 1998b). As with Lake Mendocino, flood control includes three successive flood release schedules. For Lake Sonoma, the Hacienda gage near Guerneville, located 16 miles downstream of Warm Springs Dam, is the most downstream monitoring point for decisions affecting flood control releases from Lake Sonoma.

To the extent possible, USACE manages releases from Lake Sonoma to limit flows on the Russian River at Guerneville to 35,000 cfs, which is the approximate channel capacity in Guerneville. USACE also limits releases to prevent flooding downstream along Dry Creek, which generally occurs when flows just below the dam exceed 6,000 cfs. As with releases from Lake Mendocino, USACE limits changes in releases to 1,000 cfs per hour to prevent downstream bank sloughing.

More specific directions are included in Exhibit A to the Warm Springs Dam Water Control Manual (USACE 1998b), entitled "Standing Instructions to Damtenders" (Warm Springs Dam Standing Instructions). Operation for flood control is described in the Flood Control Diagram that is summarized by Section 9b:

> *Flood Control Schedule 1, 2, and 3 releases are used to empty the flood control space following a storm. Under these schedules, releases will be limited to: (1) the discharge that does not cause the flow in the Russian River near Guerneville to exceed 35,000 cfs, and (2) the discharge that results in flow at Guerneville being less than that reached during the previous storm or storm series. The previous storm or storm series is defined as the event(s), which caused the highest pool at Lake Sonoma. In addition, releases will be limited to a maximum of: (1) 2,000 cfs if the reservoir pool did not reach elevation 456.7 feet, (2) 4,000 cfs if the highest reservoir pool reached was between elevation 456.7 feet and 468.9 feet, and (3) 6,000 cfs if the pool exceeded elevation 468.9 feet. Releases will not be increased or decreased at a rate greater than 1,000 cfs per hour. When the pool elevation is at or below 502.0 feet and inflow is at or above 5,000 cfs no gate releases will be made. Schedules 1, 2, and 3 are used only if no significant rainfall is forecasted.*
>
> *Significant rain is forecasted when the QPF is 1 inch or more for the next 24 hours or ½ inch or more for any 6-hour period in the next 24 hours. Under this condition, outflow from the lake should be limited to 2,000 cfs or less to the extent possible, so that the release can be reduced to the minimum required flow within 1½ hours if necessary. The 1½ hours includes time to travel to the control tower and make the first gate change.*
>
> *Flood Control Schedule 3 releases will be maintained until elevation 502.0 feet is reached by regulation of the outlet so that the combined flow from spills (pool above elevation 495.0 feet) and releases through the outlet works does not exceed 6,000 cfs.*
>
> *The Emergency Release Schedule is used when the pool elevation is between 502.0 feet to 505.0 feet. At elevation 505 feet and above, the flood control gates will be fully opened. The flood control gates will remain fully open until the lake has receded below elevation 505 feet, at which time the Emergency Release Schedule is again implemented. When the lake has receded below elevation 502.0 feet, Flood Control Schedule 3 is implemented.*

Because of the watershed's configuration above Lake Sonoma, direct measurement of reservoir inflow by stream gaging is impractical. Consequently, inflow is calculated as the algebraic sum of releases, changes in storage, and estimated evaporation.

Water is released from Warm Springs Dam for flood control purposes through the outlet works or through the spillway, which are located on the left abutment of the dam. The control structure accommodates multiple intakes that can be used to meet water quality requirements, as described in Section 3.2.3. Maximum discharge capacity of the outlet works is 8,100 cfs when the reservoir pool is at 513.1 feet above MSL. The spillway was designed for a discharge of 29,600 cfs, with the maximum reservoir pool elevation being 18 feet above the spillway crest.

3.2.2.1 Previous ESA Actions on Warm Springs Dam Flood Control Operations

USACE has entered into separate formal and informal consultations with NOAA Fisheries since 1997 to address the effects on coho salmon, Chinook salmon and steelhead resulting from temporary flow reductions or increases from Warm Springs Dam. In some cases, monitoring was conducted during the time work was scheduled to assess the potential for stranding fry and juvenile salmonids (see Section 3.1.2).

The temporary flow reductions and related actions conducted under previous ESA consultations are summarized as follows:

1. In July 1997, USACE provided NOAA Fisheries with a BA and requested a formal consultation under ESA Section 7 to address the effects of flow reductions resulting from proposed repair work on the Emergency Water Supply Line (EWSL) at Warm Springs Dam and the annual pre-flood inspection at Warm Springs Dam. The EWSL, which supplies water from the Warm Springs Dam outlet works to the DCFH located at the base of Warm Springs Dam,[2] was damaged during high flood releases during a flood event in January 1997. On September 30, 1997, NOAA Fisheries issued a BO and incidental take statement for these activities.

   In November 1997, USACE submitted a supplement to its July 1997 BA to NOAA Fisheries to address a vibration analysis test on the Warm Springs Dam outlet works (USACE 1997). The test, which was intended to determine the cause of damage to the EWSL and outlet works during the January 1997 event, required varying releases from below 50 cfs to over 3,000 cfs over a 2-day period. The consultation was requested under 50 Code of Federal Regulations (CFR) Sec. 402.05 (Emergencies), which provides that:

   (a) Where emergency circumstances mandate the need to consult in an expedited manner, consultation may be conducted informally through alternative procedures that the Director of the National Marine

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[2]Operation of the hatchery is described in detail in *Interim Report 2* (Fish Facility Operations) (FishPro and ENTRIX, Inc. 2000).

> *Fisheries Service determines to be consistent with the requirements of sections 7(a)-(d) of the Endangered Species Act. This provision applies to situations involving acts of God, disasters, casualties, national defense or security emergencies, etc.*

Due to dam safety concerns relating to the reliability of the outlet works, USACE proceeded with the testing in January and February of 1998. Additional tests were carried out in March 1998. A BO was not issued to USACE for these tests. NOAA Fisheries protested the additional tests performed by USACE in March 1998 that were needed to complete the analysis of the vibration phenomena on the EWSL.

2. In July 1998, USACE submitted a BA to NOAA Fisheries to address the effects of flow reductions during periodic inspections at Warm Springs Dam and Coyote Valley Dam (USACE 1998a). On September 4, 1998, NOAA Fisheries issued a BO and incidental take statement for these activities (NMFS 1998b).

3. In May 1999, USACE submitted a BA to NOAA Fisheries to address the effects of flow reductions during pre-flood inspections at Warm Springs Dam and Coyote Valley Dam (USACE 1999a). In June 1999, NOAA Fisheries issued a BO and incidental take statement for these activities (NMFS 1999d).

4. In February 2000, USACE consulted with NOAA Fisheries for emergency repairs to the EWSL at Warm Springs Dam.

   On February 17, 2000, the EWSL at Warm Springs Dam sustained damages during high flood releases of up to 4,000 cfs. Damages to the EWSL consisted of a broken support bracket, which is used to attach the water line to the side of the stilling basin. Due to a significant pressure drop in the fill line observed by project staff during the high releases, there was concern that the EWSL within the outlet tunnel may have sustained damage. On February 23, 2000, NOAA Fisheries issued a letter of concurrence with the proposed action, concluding that the flow reduction was not likely to adversely affect federally-listed species or habitat. The terms of concurrence required ramping down/up to be done in 50-to 75-cfs/hr increments and monitoring of Dry Creek.

   An inspection of the EWSL within the main tunnel and repairs to the broken support bracket were scheduled for February 25, 2000. The inspection required that the releases through the outlet tunnel be halted for 2 hours. The EWSL was used to supply approximately 28 cfs to the fish hatchery and Dry Creek below the dam. During the reduced flow period, the bracket was repaired and the EWSL within the tunnel appeared not to have sustained any damage during the high releases.

5. On March 17, 2000, USACE consulted with NMFS to inspect the outlet tunnel and perform repairs to the EWSL at Warm Springs Dam as part of the 2000 pre-flood inspections.

On May 23, 2000, repairs to the EWSL at Warm Springs Dam and inspection of the conduit required a reduction in releases to 25 cfs for 4 days. Releases were made alternately via the conduit and the EWSL.

On September 22, 2000, USACE received a letter of not likely to adversely affect federally-listed species or habitat for the Warm Springs Dam reductions in flow.

6. In July 2000, USACE consulted with NMFS for sonic meter installation at Warm Springs Dam.

   On September 22, 2000, USACE received a letter of not likely to adversely affect federally-listed species or habitat for the Warm Springs Dam reduction flow.

   Starting on October 2, 2000, for a period of 5 days, sonic meters were to be installed in the conduit at Warm Springs Dam, requiring a reduction in outflow. No stranding or mortality occurred downstream.

7. On July 11, 2001, USACE consulted with NMFS for pre-flood inspection of the outlet conduit and repairs to the outlet conduit at Warm Springs Dam.

   On August 27, USACE received a letter of not likely to adversely affect federally-listed species or habitat for the Warm Springs Dam reduction in flow. During the week of September 10, 2001, outflow from the dam was reduced to 25 cfs for 5 days to complete the repairs and inspection. No stranding or mortality occurred downstream.

8. On March 28, 2002, USACE consulted with NMFS for pre-flood inspection of the outlet conduit at Warm Springs Dam.

   On August 14, USACE received a letter of not likely to adversely affect federally listed species or habitat for the Warm Springs Dam reduction in flow.

   On September 25, 2002, outflow from the dam was reduced to 25 cfs for 2 hours for the inspection. No stranding or mortality occurred downstream.

Tunnel inspections for periodic inspections in 2003 occurred on September 25 at Warm Springs Dam, with structural inspections conducted the previous day.

3.2.3 Water Supply Operations

In the summer, SCWA releases water from Lake Sonoma for rediversion by the SCWA water transmission system, and to meet D1610 instream flow requirements. Flow regulation in Dry Creek and the lower Russian River is described in Section 3.3.

The quality of water released from Warm Springs Dam is managed for its use in the DCFH. This water passes through the hydroelectric facility before it reaches the hatchery. *Interim Report 2: Fish Facility Operations* (FishPro and ENTRIX, Inc. 2000) has additional information on historic water use of the DCFH. Water quality (including turbidity, suspended sediment concentrations, temperature, and DO) has been monitored at DCFH twice each month for as long as its operation.

The water quality of the dam outflow, including temperature, DO, and turbidity, is managed by mixing water from the low-flow tunnels that draw water from different levels of Lake Sonoma. USACE, in coordination with CDFG, determines the selection of water intake levels from Warm Springs Dam to meet the DCFH's water quality needs. This procedure also affects the water quality of releases to Dry Creek. Before 2002, the portal nearest to the lake's surface was out of service and could not be used. USACE data for dam outlet temperatures for Warm Springs Dam from January through November 1999 demonstrate that the ability to draw water from cooler depths of Lake Sonoma keep the outlet temperatures cool during summer months.

Seasonal temperature requirements for water delivered to the DFCH range from 52°F to 55°F (11.1^{o} C to 12.8^{o} C) from October through April, and 55°F to 58°F (12.7°C to 14.4°C) from May to September. It is estimated that, only during a year of maximum drawdown, or once in 50 years, will the reservoir be unable to provide water that meets hatchery temperature requirements (USACE 1998b).

3.2.4 WARM SPRINGS DAM HYDROELECTRIC FACILITY

SCWA owns and operates the Warm Springs Dam hydroelectric facility. The hydroelectric facility was completed in December 1988 at a total cost of $5 million. SCWA operates the facility under a 50-year license issued by FERC on December 18, 1984 (Project No. 3351-002). The 3,000-KW Francis turbine generator has a power rating of 2.6 MW (USACE 1984). The facility is located within the control structure of the outlet works for Warm Springs Dam.

Water from Lake Sonoma flows to the hydraulic turbine via a vertical wet well located in the control structure that draws water from the horizontal, low-flow tunnels. The upper tunnel was non-operational, but was repaired in 2002. Water from the tunnels drops between 132 and 221 feet to the turbine. Water passing through the turbine flows into the flood control tunnel to a stilling basin located at the base of the dam. A 20-inch emergency water supply line installed inside the conduit provides water to the hatchery in the event of a gate failure. This bypass line is engineered to divert water through the hatchery and to Dry Creek at a maximum flow capacity of approximately 25 cfs.

From the stilling basin, water flows through a channelized portion of Dry Creek, or is diverted for use in the DCFH adjacent to Warm Springs Dam. The stilling basin is a concrete-lined basin at the mouth of the outlet tunnel. A two-step weir, approximately 18 feet high, is used to reduce the water velocity from the outlet tunnel and to keep fish downstream of the dam from entering the outlet tunnel.

The hydroelectric facility operates during normal releases of water through the low-flow tunnels and the wet well. A minimum flow of approximately 70 cfs is needed to operate the turbine. The maximum flow capacity for the turbine is approximately 185 cfs. During flood control operations (when releases from Warm Springs Dam exceed 3,000 cfs), flow through the wet well and turbine are shut off to prevent hydraulically unstable conditions from developing in the outlet piping. When water releases of more than 500 cfs are required, service gates in the left abutment of the intake conduit are opened, and flows bypass the wet well and turbine. The minimum opening allowed for the service gates is 1 foot, which relates to a release of 500 cfs. Also, flows of 185 cfs through the turbine can continue, with the remaining flow bypassed through the service gates. However, the total flow through the wet well and the service gate must be less than 3,000 cfs.

Flows through the hydroelectric facility are determined by water supply needs and minimum instream flow requirements. The turbines can operate at flows of 70 to 185 cfs. The water supply needs and minimum instream flow requirements set by D1610 (SWRCB 1986a) generally provide flows sufficient for hydroelectric power generation, and the plant operates on flows releases for other purposes. No flow releases are made solely for the benefits of hydroelectric generation.

The Russian River system model, developed by SCWA, models flow in the Russian River basin based on minimum streamflow requirements (under D1610) and water supply demands (Flugum 1996). The model calculates the amount of power generated at model flows. Table 3-2 shows the power generated at model flows for June, July, and August of 1988 through 1995. These years encompass both *normal* and *dry* water supply conditions. All of the modeled power values exceed the minimum 1.246 MW required for SCWA to receive capacity payments under its power sale agreement with PG&E. Because releases needed to generate the minimum power requirement are lower than releases made for D1610 and water supply demands, hydroelectric operations do not control releases from Warm Springs Dam.

Table 3-2 Power Generated at Russian River Model Flows under Decision 1610

Water Year	Power (MW)
1988	2.427
1989	2.750
1990	1.382
1991	1.594
1992	4.129
1993	3.437
1994	1.606
1995	3.721

Articles 33 and 34 of SCWA's FERC license (FERC 1984) contain minimum release provisions for Warm Springs Dam that are identical to the D1610 minimum flows.[3] CDFG recommended that Lake Sonoma water level fluctuations be minimized during the

[3]Details on water supply and minimum streamflow needs are addressed in *Interim Report 3: Flow-Related Habitat* and *Interim Report 4: Water Supply and Diversion Facilities* (ENTRIX, Inc. 2002b, 2001d).

spawning period for warmwater fishes to no more than 2 feet per month. Therefore, Article 34 also specifies that SCWA "…shall for the protection of fish spawning in Lake Sonoma, operate the Warm Springs Project such that the water surface elevation of Lake Sonoma fluctuates no more than 2 vertical feet between April 1 and June 15 of each year" (FERC 1984).

The wording of Article 34 initially presented some uncertainty as to how the Warm Springs Dam hydroelectric facility was to be operated under the license. This is because other operating requirements, such as D1610 minimum streamflows and USACE flood control release criteria (USACE 1984, 1986a), require changing the surface elevation of Lake Sonoma by more than 2 vertical feet between April 1 and June 15. During the license application process, SCWA and CDFG agreed that water should not be released solely for electrical power production purposes when such releases would contribute to or cause surface fluctuations in Lake Sonoma to exceed 2 vertical feet per month between April 1 and June 15. The recitals in FERC's 1984 order stated FERC's intention to incorporate this agreement into the license without modification. SCWA's interpretation of Article 34 is that surface water fluctuations resulting from releases solely for the purpose of power production between April 1 and June 15 are limited to 2 vertical feet per month, as agreed by SCWA and CDFG, and as intended in the FERC order. In a letter dated June 2, 1989, SCWA notified FERC of its interpretation. FERC has taken no exception to this interpretation.

Because intakes to the Warm Springs Dam hydroelectric facilities are not screened, resident salmonids from Lake Sonoma could pass through the tunnels and into the turbines. Although the exact number of fish passing through the Warm Springs Dam hydroelectric facility's turbine is not known, it is expected that mortality occurs to fish passing through the turbine due to injuries either from mechanical blows or excessive pressure.

No instream work is necessary to maintain the Warm Springs Dam hydroelectric facility. All maintenance activities occur within the Warm Springs Dam control structure shaft. During any unplanned events that require shutting down the generator, automatic controls shut down flows to the turbine and open a valve that bypasses flows around the turbine unit.

3.2.5 Factors Affecting Species Environment Due to Operations at Warm Springs Dam and Lake Sonoma

3.2.5.1 Flood Control

As discussed for flood control activities at Coyote Valley Dam in Section 3.1.5.1, the change in hydrologic regime associated with flow regulation by dams can initiate a geomorphic response in the channel. Ideally, a balance, or dynamic equilibrium, occurs between periodic mobilization of the streambed, recruitment and transport of sediment, and sediment deposition and stability of spawning gravels. When flow regulation reduces the magnitude of peak-flood discharges, river channels typically modify their cross-sections by narrowing due to sediment deposition and encroachment of riparian vegetation. When the bed material consists of a sand and gravel mixture, as on Dry Creek, channel incision will often accompany channel narrowing if the flood peaks are of sufficient magnitude to mobilize most of the bed materials. Excessive channel incision often results in oversteepened streambanks and subsequent bank erosion, causing channel widening. If flood peaks are sufficiently reduced under flow regulation, the coarser bed material will not be entrained and only finer material will be transported, leading to an overall coarsening of the channel bed.

On Dry Creek downstream of Warm Springs Dam, historical aerial photographs show that the riparian vegetation has extensively encroached, causing the channel to narrow, and probably fostering channel incision. In lower Dry Creek, incision has resulted in bank erosion and a widening of the channel. When USACE constructed Warm Springs Dam, grade stabilization structures were designed and installed, in part to offset the anticipated potential effects of the dam construction, and in part to halt channel incision related to gravel mining activity in lower Dry Creek and the Russian River. The channel downstream of Warm Springs Dam has adjusted to flow regulation, gravel mining, and other land-use activities in the watershed, and is continuing to adjust, seeking a new equilibrium. With a narrower, incised, and encroached channel, the pre-dam channel-forming flows may not be appropriate for Dry Creek in its new configuration.

The alteration of the flow regime associated with dams is not the only cause of changes in channel morphology. Development in the Russian River watershed, including gravel extraction, agricultural practices, and urbanization, also influence channel geomorphic conditions. Land uses that significantly increase or decrease sediment supply (e.g., gravel mining) will cause as much alteration in channel geomorphology as flood regulation by dams. Distinguishing the effects of flood control operations from these land use effects on channel conditions can be problematic.

Significant channel geomorphic changes were apparently underway on Dry Creek before the construction of Warm Springs Dam. A study conducted by USACE concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that further channel degradation was unlikely, but that continued lateral instability and erosion of the incised channel banks was likely.

Flows in Dry Creek are still sufficiently high to mobilize the streambed and thus avoid the adverse effects of sedimentation. In addition, high flow can result in bank erosion, which recruits sediment to the channel. Currently, there is a concern that high flows (above 2,500 cfs) cause bank erosion. This concern was evaluated in *Interim Report 1* (ENTRIX, Inc. 2000a). The conclusion was that, in most years, the potential for bank erosion is relatively low and flood operations at Warm Springs Dam do not significantly contribute to prolonged flows above the threshold that initiates streambank instability and erosion.

Streambed scour during winter is still a concern relative to high flows in Dry Creek. The analysis in *Interim Report 1* (ENTRIX, Inc. 2000a) found that redds for all three species could have been lost in some years. Coho salmon were the most vulnerable to redd scour because they spawn earliest during the runoff season and have more exposure to high flows. Another contributing factor is the smaller-size gravel preferred by coho salmon for spawning. The smaller coho salmon gravels are mobilized at lower flow than suitable spawning substrate for Chinook salmon or steelhead. Coho salmon redds were predicted to scour approximately 60 percent of the time, steelhead redds only 14 percent of the time, and Chinook salmon redds 28 percent of the time (ENTRIX, Inc. 2000a). Although flow releases from Warm Springs Dam can be sufficiently high to scour redds, natural peak winter runoff on Dry Creek from tributaries downstream of the unregulated Pena Creek confluence (approximately 3 miles downstream from the dam) are also the cause of at least some spawning habitat scour. During peak runoff periods, the flow records indicate that, on some days when releases from Warm Springs Dam are relatively low (less than 200 cfs), but natural peak flows downstream of the Pena Creek confluence are much greater (over 1,000 cfs). Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow. Therefore, flood control operations are not always solely responsible for exceeding the initiation of motion threshold of spawning-size gravel.

To preserve a healthy geomorphic condition, mobilization of the bed or scour is important. The streambed should be periodically entrained to flush and transport fine sediments, thereby maintaining good-quality spawning gravels. Except for coho salmon, the results above indicate a reasonably effective balance between streambed-mobilization and spawning gravel stability for successful reproduction. Coho salmon habitat is scoured too frequently (below the Pena Creek confluence) under current conditions to provide for good reproduction opportunities in Dry Creek.

3.2.5.2 Stranding/Ramping

Annual and periodic pre-flood inspections are performed at Warm Springs Dam. Flows may be reduced in order to perform periodic maintenance activities on the dam. Since there is a bypass flow capability at Warm Springs Dam, stream dewatering is unlikely and has not occurred under recent operational practices. The bypass streamflow is generally between 25 and 28 cfs. Ramping during pre-flood inspection and maintenance activities using a 25-cfs/hr ramping rate provides adequate protection against stranding of listed species in Dry Creek.

3.3 WATER SUPPLY AND DIVERSION OPERATIONS

3.3.1 WATER SUPPLY OPERATIONS

SCWA is the wholesale provider of potable water for approximately 570,000 people in Sonoma and Marin counties. Since its creation in 1949, SCWA's role as a water supplier has evolved into two primary responsibilities:

Operation of the Russian River Project: As the local sponsor for the two federal water supply/flood control reservoir projects in the Russian River watershed (Coyote Valley Dam/Lake Mendocino and Warm Springs Dam/Lake Sonoma), SCWA, under operational agreements with the USACE, manages the water supply storage space in these reservoirs to maintain the water supply yield of the system and to maintain SWRCB-required minimum flows in the Russian River and Dry Creek. SCWA holds water rights permits to divert Russian River and Dry Creek flows and redivert water stored and released from the Lake Mendocino and Lake Sonoma.

Among the provisions contained in SCWA's water-right permits are terms authorizing maximum rates of direct diversion and re-diversion. The proportions of water diverted and re-diverted in any water year vary somewhat and depend on the amount of runoff and water demand.

Operation of the water transmission system: Downstream of Lake Mendocino and Lake Sonoma, SCWA diverts and delivers water to its wholesale customers through its water transmission system. This system consists of diversion facilities, treatment facilities, pipelines, water storage tanks, booster pump stations, and groundwater wells.

SCWA is responsible for the operation of the water transmission system through an existing water supply agreement between SCWA and eight cities and water districts in Sonoma County and northern Marin County (see Section 1.4.8), collectively referred to as the water contractors. This agreement, titled "Eleventh Amended Agreement for Water Supply" (SCWA 2001a), executed in 2001, provides for the finance, construction, and operation of diversion facilities, transmission lines, storage tanks, booster pumps, conventional wells, and appurtenant facilities. Presently, these existing facilities can meet peak deliveries at an average monthly rate of 84 mgd (which will increase to 92 mgd once Collector No. 6, currently under construction, is completed). If all of the facilities[4] contemplated by the Eleventh Amended Agreement were constructed, they would be able to meet peak-month deliveries at an average rate of 149 mgd. In addition, the Eleventh Amended Agreement contemplates that SCWA will provide 20 mgd of pump and collector standby capacity, which would allow SCWA to meet authorized water deliveries during periods when the existing diversion facilities are out of service (i.e., routine maintenance, equipment failure, system failures caused by earthquakes, floods, power outages, or other emergencies).

In addition to the Eleventh Amended Agreement, SCWA has agreements with the City of Healdsburg, the Town of Windsor, the Russian River County Water District, Camp Meeker Recreation and Park District, and the Occidental Community Services District allowing those entities to divert water from the Russian River under SCWA's water

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[4] As noted in Section 1, SCWA must complete a supplemental environmental review of the program-level impacts of the WSTSP and SCWA's Board of Directors must consider the impacts identified when determining whether to approve the WSTSP (including the construction of facilities).

rights. The analysis presented in *Interim Report 4* addresses the effects on listed fish species of operation of the water supply and transmission system under existing water rights held by SCWA (ENTRIX, Inc. 2001d). The following discussion summarized and supplements the effects analysis in *Interim Report 4*.

3.3.2 Water Demands

3.3.2.1 Historical Influences

The USACE survey report prepared before the construction of Coyote Valley Dam concluded that the ultimate consumptive use requirement for irrigation in the Russian River Valley within Sonoma County was 16,000 AF. In 1961, the SWRCB determined that sufficient water (not to exceed 10,000 AF) from the Russian River Valley within Sonoma County should be reserved for use in the appropriative water rights permit issued to SCWA to meet its future requirements for 10 years. After 10 years, any water not contracted would be made available for use elsewhere. In 1974, the SWRCB amended this permit. Amendments included elimination of the 10-year time limit, and allowing individuals to file applications with the SWRCB to appropriate water from the 10,000-AF reservation for agriculture and domestic purposes.

3.3.2.2 Current Demand Level

SCWA water-right permits are described in Section 1.4.3. Currently, SCWA is permitted to divert water to storage at Lake Mendocino and Lake Sonoma and to divert and redivert water from the Russian River at the Wohler and Mirabel pumping facilities. In water year 2001/2002, SCWA diverted and rediverted approximately 65,000 AF of water from the Russian River, including both SCWA diversions and water diverted under SCWA water rights. The total amount of water that may be diverted and rediverted under SCWA permits is 75,000 AFY, at a maximum rate of 180 cfs.

It is estimated that there are presently over 600 diversions by various entities along the mainstem of the Russian River and approximately 800 other diversions along the tributaries of the Russian River (SCWA 1996b). The uses of diverted water include municipal, domestic, agricultural, and industrial. SWRCB records list a total of over 1,500 water rights filings for the Russian River watershed. SCWA estimates that the present total diversion demand on the Russian River and its tributaries by all users, including agriculture and urban, is 110,000 to 120,000 AFY, depending on the amount of rainfall per year. Approximately 41,000 to 49,000 AFY of this demand occurs on the Russian River upstream from Dry Creek, where agricultural uses account for most of the total. Diversions along Dry Creek below Warm Springs Dam and along the Russian River downstream of the confluence with Dry Creek total approximately 70,000 AFY, including SCWA's diversions. Municipalities and agricultural interests are the primary diverters.

Approximately 12,900 AFY of mainstem water rights are senior to SCWA's and MCRRFD's water rights to direct diversion and storage in Lake Mendocino. These are not rights to water stored in Lake Mendocino, but only to water that is flowing into Lake

Mendocino. Therefore, to the extent that water flowing into Lake Mendocino would be available to satisfy these senior water rights, USACE and SCWA must allow water to pass through the Coyote Valley Dam to satisfy those senior rights.

3.3.2.3 Buildout Demand Level

More than 100 applications are pending before the SWRCB for permits to divert water from the Russian River and its tributaries. Most of these applications are for diversions on 13 different tributary systems. The total identified buildout demand is estimated by SCWA to be from 173,500 to 184,500 AFY at buildout demand level. (Buildout, as used in this BA, is defined as the demand conditions that SCWA's proposed WSTSP was designed to meet.) Approximately 58,000 to 68,000 AFY of the total buildout demand is projected to be upstream of the confluence with Dry Creek.

3.3.3 Transmission System Facilities

SCWA delivers water to its customers through its water transmission system, which currently has a reliable, summertime, average day per month delivery capacity of 84 mgd, and an allowed capacity of up to 92 mgd. The diversion and treatment facilities are located along the Russian River at Mirabel and Wohler. The distribution system includes pipelines, storage tanks, pumps, and groundwater wells, and conveys water from the diversion facilities on the Russian River to service areas in Sonoma County and in northern Marin County. The locations of SCWA's existing water transmission system facilities are shown in Figure 3-1. The operations and maintenance activities at the existing diversion facilities are described in the following sections.

3.3.3.1 Existing Diversion Facilities — Operation

SCWA's diversion facilities along the Russian River are located in the Wohler and Mirabel areas, on SCWA property (Figure 3-2). They include the inflatable dam, the Mirabel diversion facility and infiltration ponds, and the Wohler diversion facility and infiltration ponds. SCWA operates five Ranney collector wells and seven conventional wells adjacent to the Russian River near Wohler Road and Mirabel, which extract water from the aquifer beneath the streambed. Each Ranney collector well consists of a 13- to 16-foot-diameter caisson (i.e., concrete cylinder) that extends 80 to 100 feet deep into the streambed gravel. Perforated horizontal intake pipes extend radially from the bottom of each caisson to a maximum of 180 feet into the aquifer. Each collector well houses two vertical turbine pumps that are driven by 1,000 to 1,250 horsepower (hp) electrical motors.

Collector No. 6, a Ranney-type collector well and pumphouse currently under construction, is expected to commence operation in 2004. Collector No. 6 is located in the Wohler area, adjacent to the Russian River, north of Wohler Bridge and approximately 10 miles west of the City of Santa Rosa. The construction of this facility underwent informal consultation with NOAA Fisheries in 1999 (NMFS 2000b).

The ability of the Russian River aquifer to produce water is generally limited by the rate of recharge to the aquifer through the streambed near Mirabel and Wohler. To augment this rate of recharge, SCWA has constructed seven infiltration ponds (and one sedimentation pond). A water-filled inflatable dam is located on the Russian River just upstream of the Mirabel area (Figure 3-2). When the dam is inflated, it raises the water level and submerges the intakes to three diversion pumps. The water is pumped through pipes in the levee adjacent to the river into a lined ditch, which conveys water to five infiltration ponds encompassing a total area of approximately 40 acres. The backwater created by the inflatable dam also raises the upstream water level, allowing SCWA to flood two infiltration ponds (1.7 acres combined) in the Wohler area. The flow of water to these ponds is controlled by slide gates at the entrance of the canals serving each pond. The backwater created by the inflatable dam submerges a larger streambed area along the river, which increases water depth and submerged area. This significantly increases infiltration to the aquifer and increases the yield of all five Ranney collector wells.

Inflatable Dam

The inflatable dam is fabricated of a rubber material and is attached to a concrete foundation in the riverbed. When inflated, the dam is 11 feet high. The diversion facility is located on the west side of the river adjacent to the dam. The inflatable dam is usually raised in late spring when water demands increase and the Russian River flows drop below 800 cfs. The dam is lowered again in the fall or early winter when demands decline and river flows increase. Table 3-3 shows the dates that the inflatable dam was raised or lowered, and the corresponding river flows, between 1978 and 1998. During this period, the average river flow at the Hacienda gage was approximately 560 cfs when the dam was raised and lowered. Because of increasing water demands, SCWA has had to raise the dam at increasingly higher river flows. In general, the river flows are declining when the dam is raised and rising when the dam is lowered. The dam has been inflated for slightly under 7 months each year, on average. Under some spring conditions, when demands were rising sharply, the dam was raised when flows were between 1,000 cfs and 2,000 cfs. When the dam is deflated, it does not impede migration or create a backwater (Winzler and Kelly 1978).

When the dam is inflated and begins to impound water, flow over the dam is reduced, resulting in a decline of the river stage below the dam. The magnitude of the reduction in flow over the dam, and therefore the decline in stage, depends on the rate of inflation of the dam and flow in the river above the dam. Water spills over the dam until it is two-thirds inflated, at which point most of the flow passes through the ladders and associated bypass pipelines. Under current protocols, inflation of the dam generally takes approximately 12 hours to complete.

Deflation of the dam typically takes 24 hours to complete. Given that the dam is 11 feet high, stage-change in the river upstream of the dam can be estimated at approximately 0.46 ft/h during deflation.

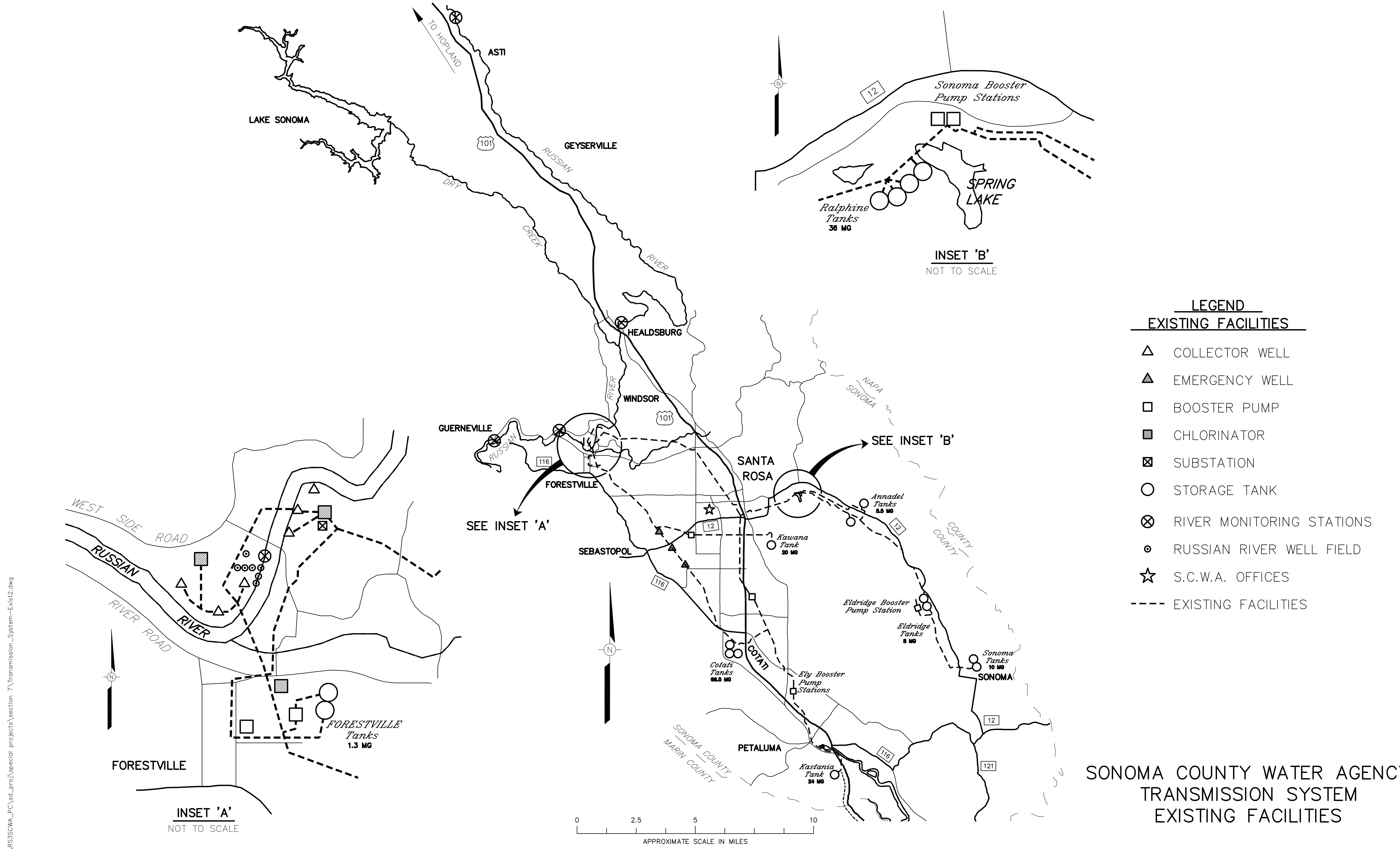

Figure 3-1 Sonoma County Water Agency Existing Transmission System Facilities

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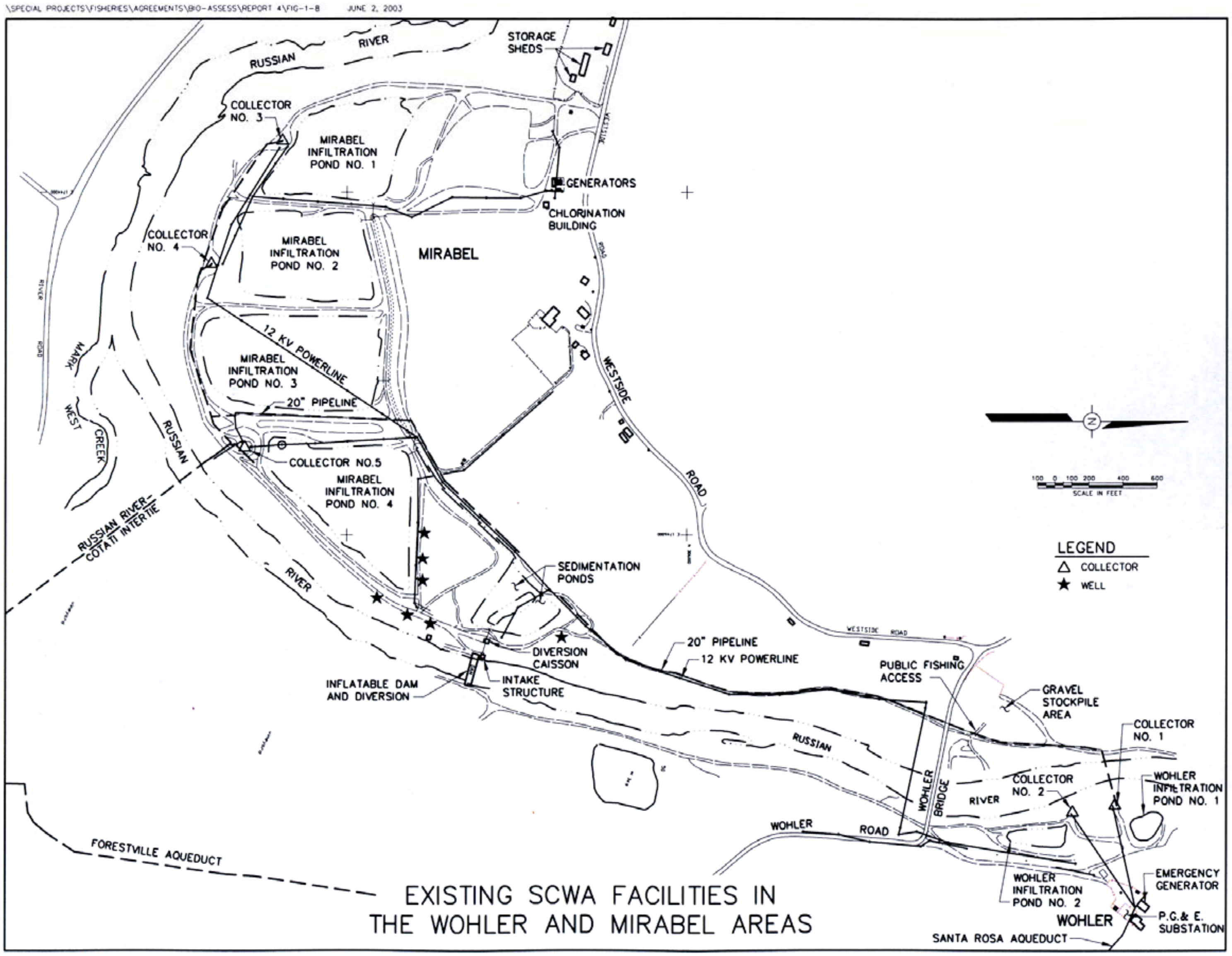

Figure 3-2 Sonoma County Water Agency Facilities in Wohler and Mirabel Areas

Table 3-3 Inflatable Dam Operation History

DATE		PRIOR 7 DAYS DEMAND LOW	DEMAND HIGH	DEMAND AVG	MAX TEMP LOW	MAX TEMP HIGH	MAX TEMP AVG	HACIENDA 8 AM FLOW (Raising)	HACIENDA 8 AM FLOW (Lowering)	7 DAY RAINFALL	SPECIAL NOTES
4/21/79	up	16.0	30.0	21.9	63	78	70			0	
10/7/79	down	26.1	31.2	28.6	75	87	80			0	
4/21/80	up	17.3	21.2	19.3	62	82	75			0.59	
9/14/80	down	32.7	37.2	34.9	71	81	77			0	
5/14/81	up	36.4	47.5	44.0	77	92	86			0	
10/7/81	down	25.4	36.3	28.9	67	87	76			0.77	
6/7/82	up	35.2	48.0	39.9	75	82	78			0	
10/7/82	down	29.4	34.2	32.2	68	80	76			0.05	
6/8/83	up	35.1	47.4	39.8	74	94	84			0	
10/19/83	down	25.8	30.4	28.1	72	78	76			0	
5/12/84	up	37.4	47.4	41.5	77	90	84			0	
10/17/84	down	29.6	35.1	32.2	57	74	69			0	
5/6/85	up	39.2	45.7	41.9	67	75	71			0	
10/21/85	down	27.4	45.9	37.5	61	82	69			1.13	
5/17/86	up	39.1	46.3	44.0	75	91	80			0	
10/21/86	down	35.9	42.8	39.3	64	77	70			0	
4/27/87	up	45.0	52.2	48.3	70	92	79	370		0	
11/12/87	down	30.1	36.2	33.5	64	68	67		248	0.38	
4/2/88	up	42.6	50.9	46.6	65	82	75	330		0	
11/2/88	down	34.2	42.3	39.0	58	75	66		174	0.15	
2/21/89	up	28.8	39.6	36.9	54	69	61	454		0.26	Hacienda flow 450 cfs North Marin Water taking 5-6 MGD extra with new pump
3/2/89	down	35.7	41.8	39.4	55	69	62		1536	2.03	Winter storm in progress HAC flow 1536 cfs
5/10/89	up	40.3	51.5	49.3	65	88	75	625		0	
10/1/89	down	34.9	47.3	42.6	70	75	72		241	0.64	Construction work for emergency diversion
10/10/89	up	40.0	51.9	46.2	74	86	79	229		0	Construction finished
10/23/89	down	35.9	49.9	42.4	53	76	65		560	2.71	STORM
12/12/89	up	31.7	39.3	35.8	55	65	59	331		0	Low rainfall YTD
1/7/90	down	30.0	38.1	33.7	51	58	55		331	1.72	STORM
4/4/90	up	37.9	45.6	41.3	63	77	67	354		0	Streamflows reduced for dry year
12/11/90	down	35.2	45.9	39.6	53	64	60		171	0.36	cool Wx. low demand
1/18/91	up	39.5	45.6	42.1	59	71	63	145		0.06	
2/2/91	down	41.2	45.1	44.1	55	66	60		278	2.23	STORM
2/13/91	up	39.2	41.8	40.5	61	73	66	246		0	
3/2/91	down	36.6	47.1	42	58	75	64		1547	3.64	STORM
5/10/91	up	38.8	49.6					465			Estimate - date inferred from records of pumping to ponds
12/23/91	down								203		Estimate - date inferred from records of pumping to ponds
1/23/92	up							351			Estimate - date inferred from records of pumping to ponds
2/9/92	down								420		Estimate - date inferred from records of pumping to ponds
4/30/92	up							553			Estimate - date inferred from records of pumping to ponds
12/2/92	down								221		Estimate - date inferred from records of pumping to ponds

Table 3-3 Inflatable Dam Operation History (Continued)

		PRIOR 7 DAYS						HACIENDA	HACIENDA		
		DEMAND			MAX TEMP			8 AM FLOW	8 AM FLOW	7 DAY	
DATE		LOW	HIGH	AVG	LOW	HIGH	AVG	(Raising)	(Lowering)	RAINFALL	SPECIAL NOTES
5/10/93	up							367			Estimate - date inferred from records of pumping to ponds
5/25/93	down								292		Estimate - date inferred from records of pumping to ponds
6/11/93	up							1120			Estimate - date inferred from records of pumping to ponds
11/9/93	down								356		Estimate - date inferred from records of pumping to ponds
3/14/94	up							708			Estimate - date inferred from records of pumping to ponds
11/9/94	down								409		Estimate - date inferred from records of pumping to ponds
12/26/94	up							837			Estimate - date inferred from records of pumping to ponds
1/3/95	down								1303		Estimate - date inferred from records of pumping to ponds
6/1/95	up							733			Estimate - date inferred from records of pumping to ponds
12/7/95	down								278		Estimate - date inferred from records of pumping to ponds
5/20/96	up							1660			
11/18/96	down								460		
3/26/97	up							477			Estimate - date inferred from records of pumping to ponds
11/16/97	down								1270		
5/23/98	up							910			
5/28/98	down								883		
6/12/98	up										
								753.8	1326.3		
								145	171		

The inflatable dam is equipped with Denil-style fish ladders near the riverbank on each side of the dam, both of which are in operation when the dam is raised. Each fish ladder has an approximate capacity of 40 cfs. Two 24- to 36-inch bypass pipelines provide water at each of the fish ladder entrances to attract adult fish to the ladder. Each bypass pipeline can allow approximately 22 cfs of flow. Downstream migrants can either pass over the dam, down the fish ladders, or through flow bypass pipes.

The bypass pipeline on the east side of the river causes excessive turbulence at the downstream entrance of the east-side fish ladder. The west-side bypass line and fish ladder function properly.

Diversion Structures and Infiltration Ponds

When the inflatable dam is raised, surface water is diverted into infiltration ponds at Mirabel and Wohler to increase water production.

<u>Mirabel</u>

At the inflatable dam, water is drawn through two rotating-drum fish screens to the diversion caisson, which houses three pumps capable of pumping a total of 100 cfs to the infiltration ponds. Diversion rates to the infiltration ponds are determined by demands on SCWA's water supply and transmission system. After flowing through a sedimentation pond adjacent to the diversion caisson, diverted water enters a small open channel, which distributes water to each infiltration pond through manually-operated slide gates.

Existing fish screens for the Mirabel pumped diversions were constructed in 1976 as part of the overall diversion facility, which included the inflatable dam foundation, inflatable dam fabric, diversion caisson, and other related equipment. The fish screens are submerged on the west side of the river in a side structure (pool), and when in operation, the screen function appears to have little variability in response to hydrologic conditions. The water surface elevation typically ranges from 37 feet to 38 feet MSL during normal summer operation.

The two fish screens at Mirabel are 11 feet in diameter, 5 feet 4 inches high, and rotate on a vertical axis. The top portion of the screens, which are submerged, have a different configuration than the rest of the screens; they are horizontal rather than vertical. Screen opening size is 5/32 inch. The diversion pumps are capable of pumping a total of 100 cfs through the screens. Vertical fixed brushes clean the screens of debris and biological fouling as the screens rotate.

Field measurements were taken to evaluate the performance of the screens in June 2000 (Borcalli & Associates 2000). Table 3-4 presents critical operating parameters for the Mirabel fish screens and compares them with NOAA Fisheries screen criteria. Most of the critical operating parameters and engineering design criteria meet NOAA Fisheries screening criteria for juvenile salmonids, but not salmonid fry. The rate of diversion during the test was 100 cfs, and the amount of water flowing through both bypass inlets simultaneously was estimated at 18.5 cfs. The approach velocities at the Mirabel screens averaged 0.18 foot per second (fps) at the downstream screen and 0.41 fps at the upstream screen. Field data indicate that large portions of the screens have approach velocities below 0.45 fps, and some areas have negative approach velocity values, indicating flows away from the screen (Borcalli & Associates 2000). There are small areas along the screens where approach velocities are higher, up to 0.95 fps. The screens rotate, while these "hot spots" remain in a stationary position. Average sweeping velocity was 1.04 fps at the upstream screen and 0.45 fps at the downstream screen. Some sweeping velocity is created as the screens turn. Test results indicate that most of the flow is pulled through the upstream screen.

Table 3-4 Critical Operating Parameters for Mirabel Fish Screens

Parameter	Mirabel Fish Screens	NOAA Fisheries Juvenile Criteria[2]	NOAA Fisheries Fry Criteria[2]
Net equivalent submerged screen area	345.6 square feet[1]		
Screen open area	40%	40% open area	27% open area
Approach velocity	Upstream: Average 0.41 fps Downstream: Average 0.18 fps	≤ 0.8 fps	≤ 0.33 fps
Sweeping velocity	Upstream: Average 1.04 fps Downstream: Average 0.45 fps	Greater than approach velocity (sufficient to sweep debris away from screen face)	Greater than approach velocity (sufficient to sweep debris away from screen face)
Screen opening size (square openings)	5/32 inches	≤ ¼ (8/32) inches	≤ 3/32 inches

1 Calculated from original construction drawing.
2 NMFS 1997

The drum screens were originally constructed with hydraulically-driven motors to rotate the drums past the vertical fixed brush, which keeps the screens free of silt and other debris. In 1995, after a leak occurred in one of the hydraulic lines, the hydraulic motors were removed and replaced with a water-jet drive system. A small water jet drives paddle blades attached to the top of the screen to rotate the screens. SCWA maintenance staff has also found that the river current itself is often adequate to rotate the screens without assistance from the water-jet drive.

Wohler

The Wohler diversion facilities consist of two ponds with a combined surface area of 1.7 acres. Currently, each pond is connected independently to the Russian River by a canal. These canals function as both inlets and outlets to the ponds. The Wohler ponds operate only when the inflatable dam is raised. Flows diverted into the Wohler ponds are not measured.

The conditions at the Wohler diversion, prior to 1999 modifications, are described in *Interim Report 4* (ENTRIX, Inc. 2001d). Prior to 1999, a screen constructed out of metal

T-posts and ¼-inch hardware cloth was installed in front of the inlet into the Wohler infiltration ponds.

Fish Rescue

The levees surrounding the infiltration ponds at Wohler and Mirabel are sometimes overtopped during floods, trapping fish in the ponds after the river level recedes. At Mirabel, this occurs only when the river rises to a gage level of approximately 37.7 feet, or 3 feet above its flood level (as measured at the Hacienda). Prior to overtopping of the Mirabel pond levees, the slide gates on the canals are opened to allow water to enter the ponds. Back-flooding of the Mirabel ponds reduces damage to the levees caused by overtopping. The canals, which are built through the levee of Mirabel pond No. 3, are typically opened when the river level reaches approximately 36 feet, as measured at the Hacienda.

Wohler pond No. 1 is overtopped when the river rises to a gage level of approximately 18.3 feet (as measured at the Hacienda), or 12,700 cfs. Wohler pond No. 2 is overtopped at 17.3 feet, or approximately 10,600 cfs. Both of the Wohler ponds have flooded for extended periods of time during most winters.

Before 1996, CDFG informally conducted post-flooding fish rescue efforts at Wohler and Mirabel facilities as needed. SCWA assumed responsibility for fish rescue efforts with the establishment of its Fisheries Enhancement Program (FEP) in 1996. Fish rescues are accomplished by wading the ponds with beach seine nets after pond levels drop to a depth where wading is possible.

3.3.3.2 Existing Distribution System – Operation

SCWA's distribution system includes pipelines (also referred to as aqueducts and interties), storage tanks, booster pump stations, and groundwater wells (Figure 3-1). Each of these facilities is operated to meet system demands. The pipeline system is designed to carry the anticipated average daily demand during the month of maximum demand (peak month), usually July or August. (Peak demand on the water transmission system reached a maximum average monthly demand of approximately 81 mgd in July 2003.)

The facilities are operated using standard BMPs and are covered by spill prevention containment and control plans and emergency operations plans that outline safe operating protocols. The emergency plans provide procedures to avoid and respond to accidental spills and releases of hazardous substances (SCWA 1998c). These plans avoid and minimize adverse impacts associated with emergencies and other unplanned events. The facilities covered by these plans include:

Reservoirs and Booster Pumping Stations

The Russian River Water System	Annadel Reservoirs 1 & 2
Cotati Reservoirs	Forestville Reservoirs
Forestville Booster Pump Station	Ralphine Reservoirs
Wilfred Ave Booster Pump Station	

Production Wells

Occidental Road Well	Sebastopol Road Well
Todd Road Well	

Mirabel – Wohler Area Pumping Plants and Chlorination Facilities

Wohler Pump Plant	pH Building – Wohler
Mirabel Chlorination Building	River Road Facilities
Cotati Intertie/Building	pH Building – River Road
Wohler Chlorination Building	Forestville Fire Department
Operations and Maintenance Service Center	

The pipeline system is designed to carry the anticipated average daily demand during the month of maximum demand (peak month), usually July or August. (Peak demand on the water transmission system reached a maximum average monthly demand of approximately 81 mgd in July 2003.)

The original pipeline system (consisting of the Santa Rosa Aqueduct, the Petaluma Aqueduct, and the Sonoma Aqueduct) was constructed in the late 1950s and the early 1960s. The two collector wells at Wohler provided the water supply to this original system. In the mid-1970s, demands in the service area increased, and the Russian River-Cotati Intertie pipeline and the three collector wells at Mirabel with connecting pipelines and additional storage tanks were authorized by the SCWA's water contractors. The Russian River-Cotati Intertie pipeline and two collectors were constructed immediately, and most of the remaining facilities were constructed in subsequent years.

Collector Wells

Ten vertical turbine pumps, two installed in each of the five Ranney collectors, provide the primary pumping for the distribution system. Each pump at Wohler is rated to deliver up to 10.0 to 11.5 mgd, and at Mirabel each pump is rated to deliver up to 10.0 to 14.5 mgd, although the highest pumping rates cannot be sustained on a continuous basis. The pumping capacity of each of the collectors is limited by aquifer constraints and heavily dependent on the current storage and pumping status of other water transmission components. For example, one Wohler pump operating by itself will produce approximately 11 mgd, three pumps operating at Wohler produce approximately 27 mgd, and four pumps produce a total of approximately 30 mgd.

Conventional Wells

Seven conventional wells, collectively referred to as the Russian River Well Field, are located in the Mirabel area, as shown on Figure 3-2. These wells withdraw water from the aquifer adjacent to the Russian River. The wells provide up to 7 to 9 mgd of additional production capacity. Water from the Russian River Well Field may either be sent directly to the Cotati Intertie, or it may be discharged into Caisson 1 and re-pumped into the Santa Rosa aqueduct.

The SCWA system includes three groundwater wells located along the Russian River-Cotati Intertie pipeline at Occidental Road, Sebastopol Road (Highway 12), and Todd Road. Prior to 1999, these wells were used for emergency purposes only and were pumped for approximately 20 minutes each month to maintain their operability.

Gaseous chlorine is added to the water produced at the Occidental Road well site to maintain protective residual levels of chlorine within the system and prevent contamination. At the Sebastopol Road and Todd Road wells, calcium hypochlorite ($CaCl_2O_2$) tablets are used on-site to generate an aqueous chlorine solution. In addition, a treatment system has been installed at the Todd Road well, which adds a small dose of an ortho-polyphosphate compound to the well water. The treatment was installed to determine whether it would be effective at eliminating the hydrogen sulfide odor, which frequently occurs in the water produced at all three wells. Although the hydrogen sulfide does not affect the potability of the water, it is a secondary water quality concern, which significantly affects its odor.

Storage Tanks and Booster Pump Stations

Storage tanks provide water storage for emergencies, to meet peak demand during maximum demand periods, and to provide hydraulic stability. Sixteen steel water storage tanks in the system provide a combined storage capacity of 118.8 million gallons. Their locations and capacities are given in Table 3-5.

Table 3-5 Location and Capacities of Water Storage Tanks

Tank Name	General Location	Number of Tanks	Total Capacity (million gallons)
Ralphine	Santa Rosa	4	36.0
Cotati	Cotati	3	36.0
Forestville	Forestville	2	1.3
Annadel #1	Santa Rosa	1	2.5
Annadel #2	Santa Rosa	1	3.0
Eldridge	Valley of the Moon	2	8.0
Sonoma	Sonoma	2	10.0
Kastania	Petaluma	1	12.0
Kawana #1	Santa Rosa	1	10.0
TOTAL		**17**	**118.8**

Operation of the water storage tanks in the SCWA system sometimes requires discharges of water from the tanks. These discharges are mostly under controlled conditions, although accidental, uncontrolled discharges may occur in some circumstances. This could result from a failure in valve control equipment, which is expected to be very infrequent.

The water transmission system also includes eight booster pump stations. Booster pumps are necessary to increase water pressure and/or to move water to areas of higher elevation. The station name, number of pumps at each station, and rated horsepower of each pump are shown in Table 3-6.

Table 3-6 Location and Rating of Booster Pump Stations

Station Name	Number of Pumps	Total Rated Horsepower
Forestville #1	2	15
Forestville #2	2	60
Sonoma #1	3	855
Sonoma #2	1	250
Wilfred	1	700
Ely	2	1,000
Eldridge	1	75
Kastania	2	650
Kawana	3	1,500

The Kawana Springs Pipeline and Kawana Booster Station were authorized prior to the WSTSP and are currently operational. The booster pump station is located in west Santa Rosa, near the intersection of Sebastopol and Wright roads.

Construction of Kawana Springs Tank No. 1 has been completed. The tank is located in an unincorporated area of Sonoma County south of the city of Santa Rosa, approximately 0.75 mile east of the intersection of Kawana Springs Road and Petaluma Hill Road. The tank location is shown in Figure 3-1. The steel tank has a capacity of 10 mg, increasing the total storage capacity of the existing transmission system to 118.8 mg.

Pipelines

The Kawana Springs Pipeline connects the Russian River-Cotati Intertie to Kawana Springs Tank No. 1. The Kawana Springs Pipeline consists of approximately 41,700 linear feet (lf) of 36-inch-diameter pipeline, and will serve to meet the demand, storage, and pressure requirements on the transmission system in the south Santa Rosa area.

The Wohler-Forestville Pipeline was also authorized prior to the WSTSP. Construction is expected to begin in early 2004. This pipeline will extend from SCWA's facilities at the Wohler area, generally parallel the existing Forestville Aqueduct for approximately 2.5 miles, and connect with the existing Russian River-Cotati Intertie pipeline near Forestville. The pipeline will consist of approximately 12,000 lf of 36- to 60-inch-diameter pipe. The pipeline will connect the 20 mgd of standby capacity provided by Collector No. 6 to the Russian River-Cotati Intertie pipeline.

The pipelines in the SCWA water transmission system include valves, which may occasionally discharge potable water to various creeks and drainage swales or ditches. These valves were installed to protect pipelines by relieving the pressure surges created when an abrupt change in flow occurs. Most, if not all, pressure surges and discharges occur when power outages trigger a sudden pump shutdown. Seventeen valves (6 slow-closing air valves and 11 surge valves) exist in the SCWA system. Potable water may also be discharged from tank overflow lines, although this occurs far less frequently. The maximum residual chlorine concentration in these discharges is approximately 0.6 parts per million (ppm). Discharges into Santa Rosa and Mark West creeks occurred in 2002 and 2003 respectively.

Cast magnesium alloy anodes are attached to the buried pipeline system at regular intervals for cathodic protection. The anodes generate a small electrical current in the pipeline that prevents corrosion on the exterior of the SCWA pipeline. These anodes are replaced after several years. The buried anodes are typically installed at every 20 to 40 feet. SCWA has an ongoing program to install anodes on approximately 2,000 to 4,000 feet of unprotected pipeline each year. Anode test stations consist of a wire lead to the ground surface, which allows the anodes to be tested without excavating the pipeline. Installation of anodes and anode test stations involves excavation with a backhoe tractor to expose the pipe joint material. Where pipelines cross creeks or other waterways, anodes are installed on either side of the crossing behind the tops of the banks. In areas where anodes cannot be installed over a significant distance, a small direct current is applied directly to the pipeline.

3.3.3.3 Existing Water Treatment Facilities – Operations

Water is diverted from the Russian River after it is filtered through the sand and gravel aquifer below the streambed and infiltration ponds, and thus requires no further filtration.

In September 1995, SCWA completed construction of pH adjustment/corrosion control facilities to limit lead and copper content in drinking water. This system was constructed in response to 1991 Environmental Protection Agency (EPA) regulations. These facilities are located at the SCWA Wohler maintenance yard and the River Road chlorination building. The facilities treat water in each of SCWA's two primary water transmission lines, the Russian River-Cotati Intertie pipeline and the Santa Rosa Aqueduct, with caustic soda. Although the water produced by the existing collectors contains no detectable levels of lead and copper, the water is naturally moderately corrosive and can leach lead and copper from indoor plumbing and water fixtures. Corrosion control treatment also assists the water contractors and other sanitation districts to meet water quality limits on the dissolved metals content in treated sewage discharges, which are even more stringent than the limits for drinking water.

SCWA currently adds approximately 0.6 ppm chlorine for disinfection at three chlorination facilities. Calcium hypochlorite is currently used at the Sebastopol Road and Todd Road well sites, eliminating the need for chlorine gas cylinders at these sites. Chlorine is stored in 100-lb. cylinders at the Occidental Road well site. Chlorine is normally delivered to SCWA’s chlorine buildings in 1-ton pressurized cylinders. The pressurized cylinders are constructed in accordance with strict regulations and are capable of withstanding severe shock if dropped. The chlorine is mixed with water inside the chlorine buildings to form a concentrated chlorine and water solution. This chlorine and water solution is transported through underground pipes to each collector. The chlorine and water solution is injected into the collector caissons to sanitize the water. The chlorine storage buildings are equipped with leak detection alarm systems that send a signal to the operations and maintenance center indicating any leak locations; the alarm also sounds at the chlorination building. Installation of chemical scrubbing systems to control leaks were completed by the end of 2003 at each of these chorine storage buildings.

The caustic soda for water treatment is purchased as a 50:50 water/sodium hydroxide solution, delivered by tanker trucks, and stored in two 10,000-gallon containers (one at Wohler and one at the River Road facilities). The Wohler pH control building is located approximately 250 yards from the Russian River. The River Road pH control building is located approximately 200 yards from Mark West Creek. The concrete masonry walls of the pH control buildings are designed to provide secondary containment to prevent the caustic soda from contaminating a large area if a leak occurs within the pH control buildings. The caustic soda is used by SCWA to raise the pH level of the water, thereby reducing the corrosion of copper pipes in household plumbing, which will help wastewater treatment facilities meet the discharge standards for copper. In its concentrated form (50 percent solution), the caustic soda has a corrosive action on body tissues. It can cause burns, deep ulcerations, and scarring. The caustic soda does not have the low boiling point of chlorine, and is safer to handle or contain in the event of an accidental spill. The primary hazard of concentrated caustic soda is its extreme corrosivity.

Minor amounts of chlorinated water are discharged from the Ranney collector wells and other nearby facilities. These may be discharges from sampling and motor cooling lines in the collector wells, which operate continuously; from pumps used to dewater the Ranney collector wells for maintenance; from the inflatable dam as it is lowered; or from other related activities. Water from motor cooling lines is discharged at an estimated rate of approximately 5 gallons per minute (gpm) when the pump motors are running. This discharged water at the Mirabel facilities flows into the settling and infiltration ponds. At Wohler, this discharge water flows into the Russian River. SCWA is currently looking into other options for cooling to alleviate this discharge. These incidental discharges and the pipeline discharges are covered under a waiver issued by the NCRWQCB in 1987 (RWQCB Resolution 87-113).

Early Warning System

The Early Warning Station Project, designed to detect the presence of contaminants in the Russian River, was initiated in 1991 in response to requirements set forth by the CDHS as part of SCWA's domestic water supply permit. Three early warning station sites were constructed in Sonoma County. Early Warning Station No. 1 is located near the Mirabel diversion facilities. Early Warning Station No. 2 is located near Mark West Creek, just downstream of its confluence with Windsor Creek. Early Warning Station No. 3 is located near the Healdsburg Memorial Dam on the westerly bank of the Russian River.

Each early warning station consists of a river intake, river sample and discharge line, biomonitor and physiochemical monitors, and auto sampler and telemetered alarm system housed within an 8-foot by 12-foot masonry or metal building. The original early warning system was designed to use the behavior of living organisms (fish or aquatic invertebrates) to detect contaminants. All three of the early warning stations are not operational due to problems with clogging filters. Because of the ongoing operation problems, the use of living organisms to detect contaminants is no longer being considered at the present time.

In October 1998, SCWA tested a water quality monitoring probe at the Mirabel diversion structure for approximately one month. The water quality probe performed well and demonstrated the performance desired by SCWA. SCWA will use these probes to monitor for DO, pH, temperature, turbidity, depth, and conductivity. The probe will not directly detect toxic materials; however, a spill in the river would be expected to alter at least one of the parameters being monitored. If an anomaly is detected, samples will be collected and sent to a laboratory for analysis. Due to the changing parameters of the project, SCWA is referring to the project as the "River Monitoring Stations Project" rather than the "Early Warning Station Project."

The River Monitoring Stations Project includes five river monitoring stations. SCWA has constructed five stations at four USGS gaging stations (located at Hopland, Healdsburg, Hacienda, and Guerneville), and one at the Mirabel diversion structure.

3.3.3.4 Existing Diversion Facilities – Maintenance

Road and Levee Maintenance

Main levee roads on the west side of the river in the Mirabel area are gravel roads that are maintained on an as-needed basis after storms. The main levee road is between 100 and approximately 250 feet from the Russian River. Maintenance generally includes grading and replacement of gravel and vegetation maintenance (mowing, trimming, and vegetation removal). This road provides access to the Mirabel collector wells, infiltration basins, diversion caisson, and the west side of the inflatable dam. This road continues north underneath the Wohler Bridge along an intertie pipeline route that connects the Wohler and Mirabel facilities. This road is also used as an access location for periodic scraping of two large gravel bars that form under and upstream of the Wohler Bridge.

Access roads at Wohler are dirt roads that are generally maintained during the spring to repair damage from high river flows that can occur during the winter months. The road is used to access the Wohler collectors, and continues south along the east side of the Russian River to access the east side of the inflatable dam. Maintenance generally consists of repairing washouts and filling potholes. This road is approximately 200 feet from the Russian River.

Inflatable Dam Maintenance

Each time the dam is lowered, the fish screens at Wohler are removed so they are not damaged during high-water events. Raising the dam sometimes requires removing gravel that has accumulated during the winter on top of the flattened dam fabric and within the fish ladders. The accumulated sediment is removed using a portable suction dredge, and discharge is directed to a temporary siltation (settling) pond to prevent turbid water from reaching the river channel. The water is allowed to re-enter the river after the sediment has settled. Spoils are then stored out of the flood plain or hauled away.

Infiltration Pond Maintenance

Because silt and other organic materials accumulate on the infiltration pond beds and gradually impede infiltration to the aquifer after sustained use during the summer, the ponds are periodically drained and the silt and organic matter removed with a grader and scraper to restore infiltration capacity. The materials are stockpiled and removed over time by private contractors.

Extensive repairs are sometimes necessary for pond and levee maintenance at the Mirabel and Wohler sites if they are overtopped during flood conditions. When the river overtops the Mirabel levee at its low points, cascading water on the inboard side of the levee causes substantial erosion damage to the levee embankment. Culverts that run through the levees at Mirabel are equipped with slide gates so they can be opened during flood conditions. If overtopping of the levees is probable, the slide gates are opened to fill the infiltration ponds and reduce erosion from water running over the top of the levees. Repairs to the levee require replacing the eroded material and rock riprap on the embankment. Flood water also deposits as much as 1 to 2 feet of impermeable silt material in the pond beds, which must be removed before the ponds can be used again. The removed material is placed on separate stockpiles at the Wohler and Mirabel sites.

Gravel Bar Maintenance

In addition to the infiltration ponds, SCWA augments infiltration rates by periodically scraping gravel bars in the river diversion areas to increase infiltration in the river. The gravel bars are graded to lower the level of the streambed so that the area is flooded when the inflatable dam is raised. A detailed discussion of gravel bar grading operations and channel maintenance activities is provided in Section 3.6.

3.3.3.5 Existing Distribution System – Maintenance

Groundwater Wells Maintenance

Operation of SCWA's Occidental Road, Sebastopol Road, and Todd Road wells frequently requires discharging well water to surface drainages for sampling or flushing purposes. These discharges usually involve unchlorinated water, although minor discharges of chlorinated water from nearby locations on the Russian River-Cotati Aqueduct pipeline may be necessary for sampling purposes. This sampling is for water quality parameters that are normally used to determine compliance with potable water regulations.

Water Storage Tanks Maintenance

Maintenance of the water storage tanks includes periodic recoating of the interior tank surfaces, which requires that the tanks be emptied. To the extent possible, the water in the tanks is drained into the transmission system. However, to maintain pressures within the transmission system, a portion must be released from the tank to surface water drainage. In these cases, the SCWA maintenance staff estimates the remaining volume and adds a corresponding amount of dechlorinating chemical (metabisulfide) to eliminate any chlorine residual in the discharge.

Controlled discharges occur approximately once every 4 years as part of maintenance activities. Controlled discharges are done only after obtaining permission from the CDHS and the NCRWQCB. The Forestville tanks are the SCWA's closest tanks to the Russian River (approximately 1 to 2 miles). Discharges from the Forestville tanks flow into a riprapped drainage ditch adjacent to the access road off Anderson Road in Forestville. Riprapping in the drainage ditches serves to dissipate the energy of discharged flows to reduce the potential for erosion. Discharges into this ditch flow in a southwesterly direction towards an unnamed tributary of Atascadero Creek approximately 0.5 miles to the south. Atascadero Creek is a tributary of Green Valley Creek, which eventually flows into the Russian River.

Overflow pipelines in each water storage tank provide a necessary emergency release route if water levels in the tank should unexpectedly rise too high. While automated control valves in the water transmission system have been installed to prevent this, overflows may nonetheless occur under certain unforeseen circumstances. In these cases, chlorinated water may be discharged to surface water drainage. At a maximum, the water in the tanks would have a chlorine level of approximately 0.6 ppm.

Equipment Maintenance

Maintenance of equipment is a continual process with varying work schedules. Maintenance of facilities occurs on a weekly, monthly, quarterly, annual, and tri-annual basis. In some cases, maintenance work on diversion and distribution facilities is performed inside the facility (inside the caisson or motor housing); in other cases, the equipment is brought back to SCWA's operations and maintenance building in Santa Rosa for maintenance. The storage yard at Mirabel is used to store small amounts of supplies needed for maintenance activities (e.g., paints, oils). Occasionally, the storage area at Mirabel is used as a staging area to store anti-freeze as part of maintenance activities associated with the diesel generators at Mirabel.

SCWA uses diesel fuel-powered generators for emergency and standby power production. SCWA has a total of approximately 31,000 gallons of diesel fuel storage capacity at various facilities. Diesel storage is located adjacent to the standby generators at the Wohler and Mirabel chlorine buildings. Both diesel storage locations are approximately 250 to 300 yards from the Russian River. Diesel fuel is stored in above-ground, double-containment tanks that are out of the floodplain. Concrete block walls around fuel tanks provide additional containment capability. Fuel tanks are designed, manufactured, and constructed in accordance with the Uniform Fire Code, the Uniform Building Code, and applicable local codes and ordinances.

3.3.4 FACTORS AFFECTING SPECIES ENVIRONMENT DUE TO WATER SUPPLY OPERATIONS

3.3.4.1 Juvenile Salmonid Emigration Delay

When inflated, the Mirabel Dam and the impoundment (approximately 3.2 miles long) have the potential to delay outmigrating smolts. Because smolts have a finite time to complete the physiological change that prepares them to survive in salt water (smoltification), a substantial delay potentially reduces survival. To evaluate the effects of baseline activities, SCWA instituted a 5-year monitoring program to assess juvenile steelhead passage.

Chinook salmon smolt emigration does not appear to be delayed by the dam (Chase et al. 2003). As part of a mark-recapture study to estimate Chinook salmon smolt abundance, smolts captured in rotary screw traps were marked on a weekly basis and transported approximately 0.8 km upstream of the dam. Marks were alternated weekly. Few Chinook salmon smolts recaptured on the day following a change in mark bore the previous week's mark, which indicates the marked fish generally required less than 48 hours to pass the dam.

Data suggest that steelhead smolt outmigration is delayed when the dam is inflated (Manning 2003). From 2000 to 2002, SCWA used radiotelemetry to evaluate steelhead migratory behavior, passage, and survival in the seasonal impoundment (Wohler Pool) created by Mirabel Dam (Manning 2003). In spring 2000, 79 yearling steelhead smolts from the DCFH were surgically implanted with uniquely coded transmitters and released in groups of 19 to 20 fish on four occasions before and after the dam was inflated. Two telemetry receivers were used to track smolts in the impoundment and automatically record passage around the dam.

During 2001 and 2002, steelhead smolt movements were recorded with four fixed radio-tracking stations, each consisting of a three- or four-element Yagi antenna and datalogging receiver. The stations were located in a riverine control reach upstream of the impounded reach, within the impoundment, and downstream of the impoundment. The fixed stations were located as follows: Station 1, at the upstream end of the 4.5 km river reach; Station 2, at the upstream end of the 5.1 km-long impoundment; Station 3, in the dam forebay; and Station 4, 50 meters below the dam. To evaluate passage routes at the dam, Station 3 was configured to simultaneously monitor an array of one aerial and six underwater antennas.

Results of the 2001 study suggested that smolt passage was slowed by shallow depth over the dam spillway and low velocities in the forebay. In spring 2002, the level of dam inflation was varied to increase depth and velocity (notch configuration).

2000 Results and Significant Findings

Radiotelemetry data from 79 radio-tagged steelhead smolts showed that the percentage of fish passing the dam site decreased over time and differed substantially before (85 to 90 percent passing) and after (42 to 50 percent passing) the river was impounded (Manning et al. 2001). With the dam inflated, between 50 and 95 percent of the smolts released spent more than 48 hours in the impoundment. Some of the steelhead smolts that eventually passed the dam resided in the reach for up to 11 days before passing. Smolt reluctance to pass the dam appeared to be related to depth and flow conditions in the forebay near the dam. The delay of some steelhead may have been exacerbated by the onset of parr-reversion (i.e., reverting back to a pre-smolt condition), stress related to surgery, and elevated water temperatures.

2001 to 2002 Significant Findings (Chase et al. 2003, Manning et al. 2003)

1. Year 2001 and 2002 data showed that steelhead smolts traveled through the riverine control reach and impoundment at roughly the same rate, despite the decreased velocity in the impoundment. The similarity in travel rates between impoundment and river suggests that delays associated with the impoundment are limited to the forebay near the dam. Differences in magnitude of flows over the study period did not appear to affect travel rate, and smolts from different hatchery-year classes performed similarly.

2. Residence time in the river above the dam did not differ significantly among years.

3. Forebay residence time was much lower in 2002 than in 2001. While small sample size may not have yielded enough statistical power to detect differences between the notched and full dam configurations in 2002, the notch may have been effective at reducing forebay residence time.

4. The ability to compare passage among years was partially confounded by the release of half the smolts at the upstream end of the impoundment in 2002. Although fish that showed little inclination to move from the upper impoundment release site were disregarded, a higher-than-expected proportion of fish from those releases failed to reach the forebay. During 2002, 47 percent of the fish entering the impoundment were never detected in the forebay–a three-fold increase over 2001. Conversely, by not accounting for some fish that would have remained in the river reach had they been released above Station 1 (the most upstream station), the proportion of fish entering the impoundment that passed the dam in 2002 was underestimated.

Environmental conditions unrelated to dam operation, such as elevated water temperatures and decreased flow, can potentially affect downstream migration. In 2000, mean daily water temperature increased from 16°C on April 20 to 23°C on June 29. Mean daily flow (measured at the USGS Hacienda gaging station) generally declined over the course of the study period. (Although storm events occasionally produced high peaks, all study fish passed the dam site before flows increased.) The percentage of radio-tagged steelhead that successfully passed over the dam decreased over time. However, the percentage of smolts that were detected but failed to pass differed substantially before and after the dam was inflated. This indicates that the dam affected passage.

Dye-marked steelhead smolts (released in conjunction with radio-tagged steelhead) in the forebay of Mirabel Dam on May 23, 2000 were observed to swim against the current near the dam and avoid being swept over the dam. The combined effects of low attraction velocities at the bypasses and ladders, shallow water at the crest of the dam, and rapid acceleration of flow over the crest of the dam may discourage smolts from passing the dam (Manning 2001).

Chinook salmon passage may be more successful because Chinook salmon smolts are smaller than steelhead smolts (Chase et al. 2002) and may be more likely to pass over the dam or through the bypasses and ladders.

3.3.4.2 Entrainment and Impingement at Fish Screens

Mirabel Diversion Fish Screens

Engineering design and critical operating parameters for the two fish screens at the Mirabel diversion mostly meet NOAA Fisheries criteria for juvenile salmonids. Although some small areas on the screens have approach-velocities higher than NOAA Fisheries criteria, particularly on the upstream screen, the risk of impingement on the screens for juvenile salmonids is low.

Because the Mirabel screen design is not within NOAA Fisheries criteria for salmonid fry (juvenile fish less than 60 mm long), there is a higher risk of impingement or injury to salmonid fry. SCWA screw trap data from 2002 have documented hundreds of Chinook salmon juveniles smaller than 60 mm FL during the Chinook salmon downstream migration period (Chase et al. 2002), although thousands of Chinook salmon were documented. Weekly average Chinook salmon lengths were greater than 60 mm FL beginning in April, but Chinook salmon smaller than 60 mm were documented through the week of June 17. Average weekly YOY steelhead lengths were greater than 60 mm FL after the week of May 14. These data indicate that steelhead and Chinook salmon fry present in the early spring are at risk. However, the diversion is less likely to be in operation in early than late spring. Coho salmon fry are more likely to utilize tributary habitat and are therefore at a very low risk.

Wohler Diversion Fish Screens

Wohler diversion screen design and operation are not within NOAA Fisheries criteria for juvenile or fry. Young fish exposed to the facility have a high risk of entrapment, impingement, injury, or migration delay. In some years, the diversion may be operated earlier or later than the normal May-November period. However, the diversion is normally operated during a small portion of the coho salmon and Chinook salmon outmigration period and a larger portion of the steelhead outmigration period (approximately 40 percent overlap). Only 5 percent of the total river flow is diverted at Wohler. Combining these two components, juvenile coho salmon and Chinook salmon downstream migrants are at a low-to-moderate risk for entrapment, impingement, injury, or migration delay, primarily because the Wohler diversion operation does not overlap substantially with the juvenile outmigration period. The risk for steelhead entrapment, impingement, or injury is higher because the diversion operates during a greater portion of the juvenile outmigration period; therefore, steelhead juveniles are at moderate risk.

As discussed with the Mirabel diversion fish screens, Chinook salmon and steelhead fry present in the early spring are at risk of entrapment, but coho salmon fry are at a very low risk.

3.3.4.3 Overtopping at Mirabel and Wohler Ponds

Flood flows periodically overtop the river bank and flood the Mirabel and Wohler infiltration ponds. When floodwaters recede, fish may be entrained in the ponds.

Mirabel

Potential effects to listed fish species were evaluated in *Interim Report 4* (ENTRIX, Inc. 2001d). Of 35 water years modeled, Mirabel ponds would have overtopped 28 days or approximately 0.1 percent of the time. The ponds would have overtopped in December through March. Because the ponds at Mirabel do not overtop often, the opportunity for entrainment at Mirabel during high flows is small.

Because less than 5 percent of streamflow during flood events enters the Mirabel ponds, and the ponds overtop during only a very small portion of the steelhead juvenile migration period, steelhead are subject to low risk. Coho salmon and Chinook salmon juveniles are more likely to migrate through the area when the ponds overtop. They would be subjected to a moderate risk of entrapment or migration delays. However, the ponds do not overtop very often; thus, individual fish may be affected but the overall risk to the populations is low. Chinook salmon were found in the Mirabel ponds during rescue operations in 1998. Although some fish may be lost to injury or stress during rescue operations, rescue operations at the Mirabel infiltration ponds minimize the overall risk to the three listed fish species.

Wohler

The Wohler ponds were at a greater risk of being overtopped and flooded by the river than the Mirabel ponds. Computer simulations estimate that Wohler pond No.1 would have overtopped 533 days over 35 years, or 4 percent of the time, and Wohler pond No. 2 approximately 625 times (5 percent of the time). The Wohler ponds flood almost every year. In general, flooding occurs during November through April. The Wohler ponds are relatively small (1.7 acres combined), so only a small portion of the mainstem flood flow enters the ponds. Because Wohler Ponds overtop more frequently, the risk to listed fish species is higher than at the Mirabel ponds. SCWA has conducted fish rescues in the Wohler ponds when needed since 1996.

3.3.4.4 Stranding or Displacement from Flow Fluctuation from Inflation and Deflation of the Inflatable Dam

When the inflatable dam is raised or lowered, water levels downstream and upstream, respectively, of the dam can drop, creating an opportunity for stranding juvenile fish downstream or upstream of the dam.

Deflation

When the inflatable dam is lowered, flow recessions and dewatering of habitat occurs in 2 miles of river upstream, which could result in stranding of salmonids. *Interim Report 4* evaluated this risk (ENTRIX, Inc. 2001d). Generally, habitat in the reach that is affected by impounded water does not have characteristics conducive to stranding. The dam is not lowered frequently (on average less than two times per year), the channel shape presents little risk of stranding, and dewatering of the riverbed is unlikely. Therefore, deflation of the inflatable dam presents a low risk of stranding to juvenile salmonids if it is performed slowly enough. SCWA staff have noted stranding of warmwater fish species in one instance when the dam was deflated too quickly, but no stranding of salmonids has been observed.

Inflation

Inflation of the dam usually occurs when river flows have declined from winter levels. Although water may continue to spill over the dam during inflation, flow recessions occur downstream of the inflatable dam. Because river flows are often lower during dam inflation than deflation, and downstream habitat is more complex; the risk of stranding fish is higher.

The risk of stranding juvenile fish when downstream water levels recede depends, in part, on habitat features in the river channel. At low flows, habitat downstream of the dam includes shallow water habitats (riffles) that increase the risk of fish stranding during flow recessions. Flow from Mark West Creek and Laguna de Santa Rosa attenuate flow recessions caused by dam inflation in downstream reaches of the river. As flows from these watersheds decrease in the spring and summer, the level of this attenuation decreases.

Stage-changes at the USGS gage at Hacienda were evaluated for a series of ten inflation events covering a range of initial river flows. Typically, maximum stage-change at Hacienda occurs within the first few hours, before flow through the bypass pipelines is initiated. Maximum stage-changes ranged from 0.06 to 0.38 foot per hour. Stage data from the USGS gage at Hacienda during dam inflation under current protocols showed a stage recession of 0.08 foot per hour on April 22, 2001 (a *dry* year) and a maximum stage recession of 0.38 foot per hour on April 16, 2002.

However, the Hacienda gage is not directly downstream of the dam, and flow from the Mark West Creek and Laguna de Santa Rosa watersheds may have influenced stage-changes at the gage. Stage-changes closer to the inflatable dam are larger.

3.3.4.5 Temperature

When the inflatable dam impounds water, water temperatures may increase. Similar effects may occur related to deepening areas of gravel bars downstream of the dam. An ongoing SCWA 5-year monitoring study (initiated in 2000) is producing data to assess potential effects. The inflatable dam operation is basically a run-of-the-river operation, and data suggest only a slight increase in water temperature through the Wohler Pool (approximately 0.5°C in August) (Chase et al. 2002). Steelhead rearing may occur in the area, but coho salmon are thought to use the area solely for passage. Chinook salmon juveniles migrate out by the end of June. By summer, temperatures in the inflatable dam impounded area, as well as free-flowing areas above and below the dam, are warmer than published water temperature criteria for salmonids. This small increase in temperature (0.5°C) in August is not likely to affect smolts, which migrate through the area earlier in the year, but may slightly reduce the quality of rearing habitat during the summer.

3.4 FLOW MANAGEMENT

3.4.1 FLOW REQUIREMENTS UNDER D1610

Lake Sonoma and Lake Mendocino are currently operated in accordance with criteria established by D1610 (SWRCB 1986b). D1610 adopted, with one minor change, the criteria included in an agreement between CDFG and SCWA that established minimum flow requirements for Dry Creek and the Russian River (SCWA and CDFG 1985). Minimum streamflows under D1610 are specified for four different reaches in the Russian River watershed: the East Fork Russian River from Coyote Valley Dam to the confluence with the mainstem, the mainstem Russian River between the East Fork Confluence and Dry Creek, the mainstem Russian River between Dry Creek and the mouth, and Dry Creek downstream of Warm Springs Dam to the confluence with the Russian River. D1610 represents the baseline minimum instream flow conditions evaluated in the BA.

Under D1610, required minimum flows in both the upper and lower Russian River vary depending upon water supply condition. Water supply condition is determined based on the cumulative inflow to Lake Pillsbury on the first of each month between January and June and is represented as *critically dry*, *dry*, or *normal*. The water supply condition can vary from month to month until June 1 when it becomes set until the following January.

Within the *normal* water supply condition, there is a separate schedule referred to as the *dry spring* criteria that is dependent upon the total combined storage in Lake Mendocino and Lake Pillsbury on May 31 of each year. The *dry spring* criteria affect releases from Lake Mendocino. These criteria allow reductions in minimum flows for the mainstem Russian River when the combined storage falls below 90 percent and 80 percent of the combined capacities of Lake Pillsbury and Lake Mendocino. This provision reflects the “flashy” hydrology of the basin and the fact that the water supply is dependent on not only the quantity of runoff, but also the timing of runoff. Flood control operations do not allow conservation of winter runoff so fully filling the water supply pool requires spring runoff. Historically, in approximately 11 percent of years, *dry spring* water supply conditions prevail from June through December. *Dry spring* conditions do not apply to the January through May period.

Figure 3-3 summarizes the minimum flow requirements contained in D1610. In the Russian River system, minimum flow rates are required to be maintained throughout entire reaches of the river, rather than at specified points. In the Russian River between Lake Mendocino and Healdsburg, separate minimum flow requirements apply to the short reach between Lake Mendocino and the mainstem Russian River, and to the mainstem between the confluence of the East Fork and Dry Creek. The point on the river with the lowest flow, referred to as the controlling point, determines the reservoir release. The location of the controlling point changes during the year. In the winter, when flows are increasing downstream, the controlling point is just below Coyote Valley Dam. In the summer, when tributary inflows have receded and flows are reduced by diversions, the controlling point is the Healdsburg gage. The transition from upstream to downstream control usually occurs during a period of 1 to 3 weeks in May or June, depending on the amount of spring rainfall. D1610 sets separate minimum instream flow requirements for the lower Russian River below Healdsburg and for Dry Creek.

The flow requirements under D1610 for the Russian River from Lake Mendocino to the Dry Creek confluence were based in part upon an evaluation of fish habitat and migration barriers (Winzler and Kelly 1978). These flow requirements were intended to maintain the highest sustainable flows possible to support the steelhead and salmon fishery below Coyote Valley Dam and instream recreation, and to avoid dewatering Lake Mendocino (SWRCB 1986b). The flow requirements were set with the assumption that the water supply available from Lake Mendocino would be sufficient to satisfy flow needs between Lake Mendocino and Dry Creek, and expected authorized diversions along this reach of the Russian River.

The instream flow requirements for the Russian River downstream from its confluence with Dry Creek during *normal* water supply conditions were based primarily on a desire to maintain flows upon which the recreational canoeing industry on the Russian River had previously developed. The reduced minimum instream flow requirements for *dry* and *critically dry* water supply conditions were determined in consideration of warmwater fish and wildlife needs, particularly for the lower portion of the Russian River.

The flow requirements for Dry Creek were based on the CDFG instream flow needs investigation performed in 1975 and 1976 (Barraco 1977). These requirements were developed to meet the fish spawning, passage, and rearing needs as determined by CDFG at that time. These flows were to sustain the native fish populations below Warm Springs Dam, to enhance steelhead and salmon spawning and nursery habitat in Dry Creek, and to facilitate operations of the DCFH at Warm Springs Dam.

Flows in the Russian River from Healdsburg to its mouth at Jenner are managed in much the same manner as the Russian River above Healdsburg. Lake Sonoma water supply releases operate under the general rule of discharging water necessary to satisfy demands (mostly SCWA's) between Dry Creek and the Hacienda gage, and to meet the minimum flow requirement at Hacienda. Under current demands, during *normal* water supply

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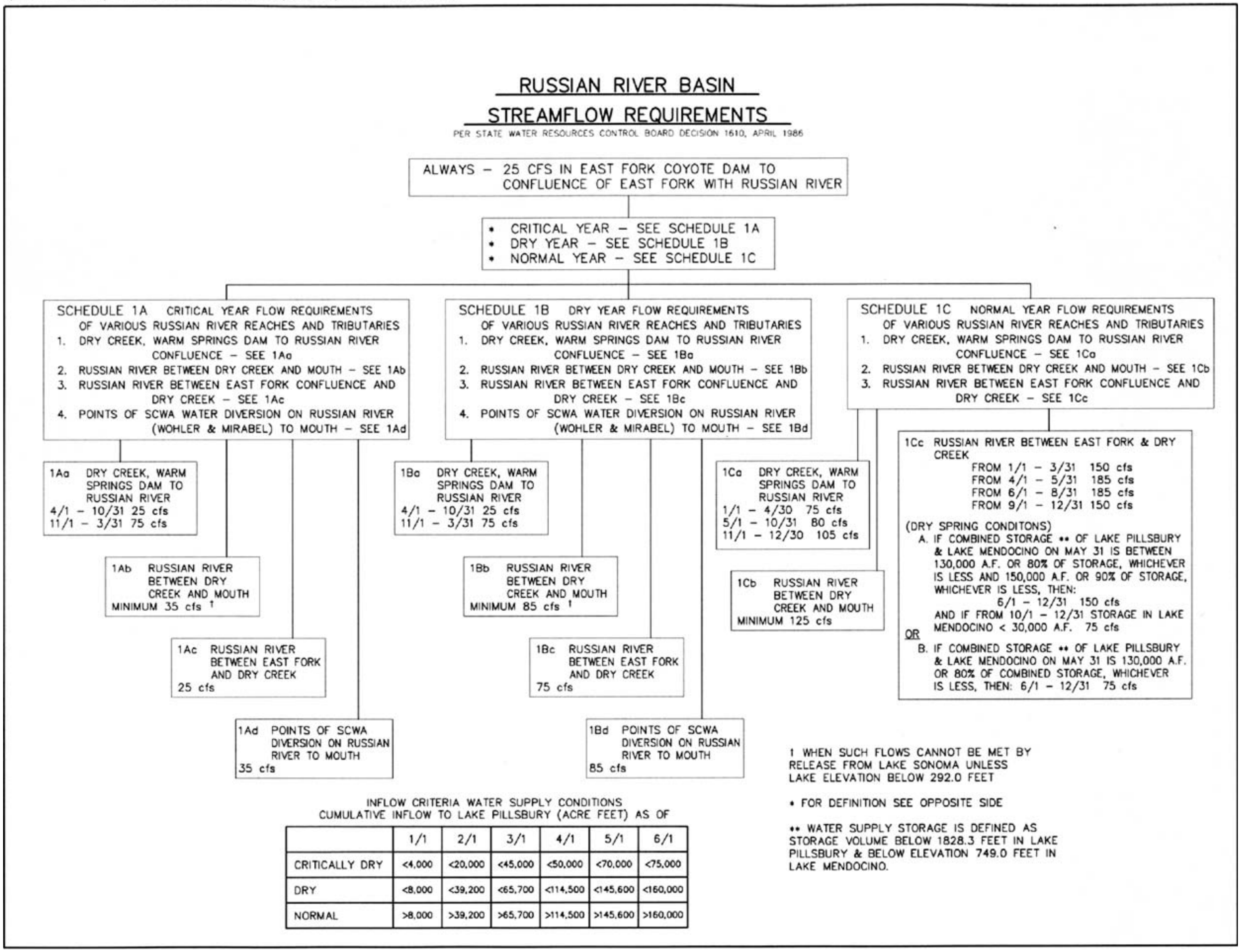

	1/1	2/1	3/1	4/1	5/1	6/1
CRITICALLY DRY	<4,000	<20,000	<45,000	<50,000	<70,000	<75,000
DRY	<8,000	<39,200	<65,700	<114,500	<145,600	<160,000
NORMAL	>8,000	>39,200	>65,700	>114,500	>145,600	>160,000

Figure 3-3 D1610 Russian River Basin Streamflow Requirements

conditions in the summer, releases from Lake Sonoma are typically controlled by the required minimum flows in Dry Creek and the lower Russian River. During *dry* and *critically dry* summers, releases are often controlled by water supply needs.

During the winter months, USACE controls releases from Coyote Valley Dam and Warm Springs Dam to provide flood protection to downstream areas. In doing so, USACE captures high flows during high runoff events and releases these flows at a lower magnitude over a longer period. The two dams control runoff from a relatively small proportion of the watershed, so winter river flows are largely governed by local runoff from unregulated tributary streams. Winter flow levels are typically much higher than summer flow levels.

3.4.2 Operational Considerations in Flow Regulation

For the purpose of managing water supply releases from Lake Mendocino and Lake Sonoma, the river can be evaluated in two sections: 1) the Russian River between Lake Mendocino and Healdsburg; and 2) the Russian River from Healdsburg to Jenner, including Dry Creek.

SCWA must release enough water from Lake Mendocino and Lake Sonoma to meet downstream water demands, and ensure that releases are adequate to meet minimum flow requirements in the Russian River and Dry Creek. Several factors affect the amount and timing of water supply releases. These factors include the length of time it takes water to travel from the reservoirs to downstream monitoring points, changes in weather, and variability in water demands and diversions. SCWA does not control diversions other than those made at its diversion facilities.

Under D1610 during *normal* water supply conditions in the summer, minimum flows in the mainstem Russian River are 185 cfs at the confluence of the East Fork and 125 cfs at Guerneville. Under current demand during a normal summer, SCWA must release up to 300 cfs, and occasionally more, from Lake Mendocino to satisfy demand and meet the 185-cfs minimum flow requirement at Healdsburg. Because a change in release at Lake Mendocino may take up to 3 days to appear at Healdsburg (SCWA 1999a), SCWA maintains an operational margin of 10 to 20 cfs above the release necessary to meet the minimum flow requirement (taking into account non-SCWA diversions). This provides the buffer necessary to ensure that, as water use and diversions fluctuate, the minimum flow requirements will be met. To determine the effects of adjustment to the release, SCWA must allow downstream flows to stabilize before making additional modifications to the releases.

Under D1610, minimum flows were established for the reach of Dry Creek between Warm Springs Dam and the confluence with the Russian River to assure fish passage during upstream spawning runs and downstream migrations. Required minimum flows are determined by water supply condition (see Figure 3-3). Under baseline conditions, actual summer flows in Dry Creek are largely determined by water demand.

3.4.3 MODELING OF FLOW AND TEMPERATURES

SCWA has modeled D1610 flow and water temperature using the Russian River System Model (RRSM) (Flugum 1996) and the Russian River Water Quality Model (RRWQM) (RMA 2001). These models were used to simulate the flow and water quality conditions that would exist under current and projected future (buildout) water demand conditions. Flow was modeled for each of four locations on the upper (Ukiah), middle (Cloverdale and Healdsburg), and lower (Hacienda) Russian River and on Dry Creek (Figure 1-1). The upper Russian River is represented by the Ukiah and Hopland nodes within the model (Table 3-7). The middle Russian River is represented by the Cloverdale and Healdsburg nodes. The lower Russian River is represented by a node in the Russian River downstream of the confluence of Dry Creek (Below Dry Creek) and at the Hacienda near Guerneville (Hacienda). The Hacienda node also estimates inflow to the Estuary.

Table 3-7 Location of Nodes Used to Model Flow in the Russian River and Dry Creek

River Reach	Model node
Upper Russian River	Ukiah
	Hopland
Middle Russian River	Cloverdale
	Healdsburg
Lower Russian River	Below Dry Creek
	Hacienda
Dry Creek	Warm Springs Dam
	Lower Dry Creek

Dry Creek is represented by two nodes: one downstream of Warm Springs Dam (Warm Springs Dam) and one upstream of the Healdsburg diversion (Lower Dry Creek).

The mean daily flows that were equaled or exceeded 50 percent of the time (50 percent exceedance flows) are presented for *all* water supply conditions combined and for *dry* water supply conditions. *All* water conditions represent the full 90-year period (1910 to 2000) simulated in the RRSM, including *dry* and *critically-dry* water supply conditions. *Dry* water supply conditions within this document combine *dry* and *critically dry* water supply conditions (Table 3-8).

3.4.4 PROJECTED FLOWS UNDER D1610

3.4.4.1 Current Demand Levels

Under current water demand levels and *all* water supply conditions, the median flows from June through October range from approximately 164 to 261 cfs in the middle and upper Russian River (Table 3-8). Because of diversions, losses to groundwater and evaporation, flows decline with distance downstream from the Forks from July through October. From Dry Creek to Mirabel, flows are higher due to the inflow from Dry Creek, ranging from 246 to 320 cfs. At Hacienda, flows are again lower, primarily due to diversions at SCWA's Mirabel facilities. These flows are more similar to those in the upper Russian River, ranging from 148 to 279 cfs. During the winter months flows increase with distance downstream from Coyote Valley Dam due to inflows from unregulated tributaries. The median flows from November through May range from approximately 170 cfs to 2,200 cfs in upper and middle Russian River and from approximately 275 cfs to 3,900 cfs at Hacienda.

Under current demand levels and *dry* water supply conditions, the median flows from June to October range from 89 to 177 cfs in the upper and middle Russian River. Between the confluence of Dry Creek and Mirabel, flows range from 186 to 206 cfs. At Hacienda, flows range from 92 to 102 cfs from June to October. During the wet season (November to May) median flows range from 113 cfs to approximately 1,200 cfs in the upper and middle Russian River, while flows at Hacienda range from 156 to 1,824 cfs.

In Dry Creek under *all* water supply conditions at current demand levels, the median flows range between 81 cfs and 103 cfs from June to October. During this period, flows are typically lower at the lower end of Dry Creek. Flows typically increase during November to May, and the median flows range between 76 cfs and 482 cfs. During November to May, Dry Creek is typically a gaining reach due to tributaries inflow, and flows in lower Dry Creek are higher than those below Warm Springs Dam. Under *dry* water supply conditions in Dry Creek, median flows during June to October range between 77 cfs and 129 cfs. The winter and spring flows range between 26 cfs and 150 cfs.

3.4.4.2 Buildout Demand Levels

Under Buildout demand Levels, the RRSM predicts that flow levels under *all* water supply conditions during June to October will range from 164 to 273 cfs in the Upper and Middle Russian River, which is very similar to flows under current demand levels. Between the confluence of Dry Creek and Mirabel, flows would increase, as the increased water demand would be met through increased releases from Lake Sonoma. Flows in this section of the river would range from 260 to 330 cfs. At Hacienda, flows would be lower than under current demands, ranging from 137 to 202 cfs. During November to May, flows at Ukiah would range from 173 to 925 cfs, while flows at Hacienda would range from 228 to 3,654 cfs.

Under *dry* water supply conditions under buildout demand levels, flows from June through October would range from 109 to 195 cfs at Ukiah, with flows decreasing with distance downstream of the Forks to the confluence of Dry Creek. Between the mouth of Dry Creek and Mirabel, flows would range from 220 to 304 cfs, as much of the demand served by SCWA's facilities would be met out of Lake Sonoma. At Hacienda, flows would range from 93 to 100 cfs from June to October. During the wetter portion of the

Table 3-8 Median Daily Flows (cfs) in the Russian River and Dry Creek for D1610

Current Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	736	927	516	602	304	235	261	231	179	173	167	348
Hopland	844	1095	624	683	323	233	250	222	174	170	167	389
Cloverdale	1084	1404	853	831	365	232	234	209	167	168	171	461
Healdsburg	1632	2182	1418	1196	500	237	208	200	164	169	183	598
Below Dry Creek	2016	2950	1970	1450	606	320	292	282	246	248	295	753
Hacienda	2595	3867	2656	1796	702	279	197	174	148	163	276	865
Below Warm Springs Dam	76	278	255	134	81	95	103	93	85	81	106	106
Lower Dry Creek	200	482	368	196	92	87	89	87	84	83	111	135

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	148	570	275	238	173	176	177	119	114	106	113	153
Hopland	186	633	356	273	175	165	162	111	107	102	114	177
Cloverdale	263	778	535	326	189	151	141	99	96	98	123	239
Healdsburg	440	1182	838	442	217	112	98	89	89	95	127	335
Below Dry Creek	579	1382	1062	499	250	195	205	206	201	186	206	425
Hacienda	725	1824	1496	572	249	102	92	95	96	96	156	430
Below Warm Springs Dam	76	76	76	26	26	88	129	127	117	91	76	76
Lower Dry Creek	110	150	146	53	38	77	114	121	115	91	79	96

Buildout Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	705	925	514	599	306	242	273	240	185	177	173	340
Hopland	812	1081	617	678	326	237	259	229	179	174	176	385
Cloverdale	1046	1398	851	827	364	235	239	214	171	171	183	462
Healdsburg	1580	2128	1387	1175	478	237	209	200	164	170	178	587
Below Dry Creek	1891	2752	1892	1427	584	330	328	323	279	260	288	754
Hacienda	2482	3654	2543	1739	611	202	139	139	137	140	228	842
Below Warm Springs Dam	76	158	208	115	81	104	139	143	126	89	106	106
Lower Dry Creek	195	382	328	184	94	95	118	129	118	92	111	138

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	149	534	279	231	194	195	195	129	123	109	110	143
Hopland	176	595	363	257	194	180	177	120	114	105	113	145
Cloverdale	226	730	539	308	202	153	149	104	101	100	122	158
Healdsburg	392	1141	809	411	227	113	100	90	90	96	112	203
Below Dry Creek	533	1325	1023	462	298	266	304	286	248	220	208	296
Hacienda	652	1733	1363	510	202	96	93	97	100	93	127	308
Below Warm Springs Dam	76	76	76	26	26	172	236	217	171	124	82	76
Lower Dry Creek	110	144	144	56	48	153	213	203	162	125	97	114

year under *dry* water supply conditions flows at Ukiah would range from 110 to 534 cfs, with higher flows with increasing distance downstream of the Forks due to accretion from tributaries. At Hacienda, flows during this time of year would range between 127 and 1,733 cfs in *dry* water supply conditions.

In Dry Creek, flows would increase during the summer months, as most of the increased demand would be met through additional releases from Lake Sonoma. From June to October, flows would range from 89 to 143 cfs under *all* water supply conditions, and from 124 to 236 cfs under *dry* water supply conditions. From November to May, flows would range from 76 to 382 cfs under *all* water supply conditions and from 26 to 144 cfs under *dry* water supply conditions.

3.4.5 PROJECTED WATER TEMPERATURES UNDER D1610

Temperatures generally increase with distance below the two dams from March through September under both water supply conditions. During October through February, water temperatures are generally constant or decrease slightly with distance below the dams.

RRWQM simulations indicate that temperature conditions in the Russian River and Dry Creek would generally be within a suitable range for salmonids from November through April, but would be very stressful for salmonids below Healdsburg during July and August (Table 3-9).

3.4.5.1 Current Demand Levels

Under current water demand levels and *all* water supply conditions, median monthly temperatures range from 15.8°C to 19.8°C at Ukiah from June through October. Temperatures become warmer with distance downstream from the Forks. Temperatures are slightly stressful at Cloverdale, during this time period, ranging from 18.1°C to 20.5°C. At Healdsburg, temperatures are generally stressful, ranging from 18.6°C to 23.6°C, and are very stressful in July and August, when water temperatures exceed 23°C. Water temperatures are moderated somewhat by the influence of flows from Dry Creek, but remain warm, exceeding 22°C in July and August. At Hacienda, water temperatures again exceed 23°C in July and August and range between 18.3°C and 23.5°C between June and October. From November through May, water temperatures are cooler, ranging from 8.6°C to 15.1°C at Ukiah and 9°C to 18.4°C at Hacienda.

In *dry* water supply conditions under current demand levels, temperatures are similar (within 0.5°C) to those under *all* water supply conditions from November through July. In August through October, water temperatures in the upper Russian River are cooler by 1 to 1.5°C. This cooling is observed downstream to Cloverdale, but is not evident at Healdsburg. Below the mouth of Dry Creek, cooler temperatures are again evident during the summer months due to higher releases from Warm Springs Dam. This cooler water is not observed at Hacienda, however, except in July.

In Dry Creek, water temperatures are similar below the dam regardless of water supply condition, ranging from 12°C to 13.3°C throughout the year. During April through

Table 3-9 Median Temperatures in the Russian River and Dry Creek under D1610

Current Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	8.6	9.3	11.3	12.6	14.4	15.8	16.1	18.1	19.8	19.7	15.1	10.7
Hopland	8.6	9.4	11.7	13.4	16	18	18.5	19.7	20.4	19.3	14.8	10.6
Cloverdale	8.5	9.4	11.9	14	16.9	19.1	19.9	20.5	20.4	18.9	14.7	10.5
Healdsburg	8.5	9.8	12.6	15.6	19	21.8	23.6	23.3	21.6	18.6	14.3	10.1
Below Dry Creek	8.8	10.1	12.7	15.5	18.8	21.2	22.6	22.2	20.5	17.7	13.9	10.4
Hacienda	9	9.9	12.2	15	18.4	21.4	23.5	23.4	21.6	18.3	14	10.6
Warm Springs Dam	12.4	11.8	12.8	12.9	13	13.2	13.2	13.1	13.1	12.9	12.7	12.7
Lower Dry Creek	10.3	10.9	13	14.7	16.7	17.8	18.3	17.9	16.8	15.1	13.1	11.6

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	9.4	9.5	11.4	13.3	14.9	15.4	15.5	17	17.4	18	15.2	11.2
Hopland	9.7	9.7	11.9	14.5	16.7	18.1	18.4	19.5	19.1	18.1	14.8	11
Cloverdale	9.7	9.7	12	14.7	17.3	19	19.9	20.3	19.5	18.2	14.6	10.8
Healdsburg	9.4	10	12.7	16	19.4	21.7	23.8	23	21.3	18.5	13.9	10.1
Below Dry Creek	9.8	10.2	12.8	16	19.1	20.9	21.3	20.4	19	17.3	13.6	10.2
Hacienda	9.6	10	12.2	15.2	18.6	21.6	23.6	22.7	21	18.2	13.6	10.4
Warm Springs Dam	12.7	12.7	12.8	13.1	13.2	13.2	13.1	13.1	13	12.9	12.8	12.7
Lower Dry Creek	11.2	11.3	12.9	15.4	17.4	17.9	17.6	17	16.1	15.1	13.1	11.4

Buildout Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	8.5	9.2	11.3	12.6	14.4	15.8	16.4	18.6	20.8	19.8	14.9	10.4
Hopland	8.5	9.4	11.7	13.4	16	17.9	18.6	20	21	19.3	14.6	10.3
Cloverdale	8.4	9.4	11.9	14.1	16.9	19.1	20	20.8	20.8	18.9	14.6	10.2
Healdsburg	8.5	9.8	12.6	15.6	19	21.8	23.6	23.4	21.7	18.6	14.2	10
Below Dry Creek	8.8	10.1	12.7	15.5	18.8	21.1	22.1	21.5	19.9	17.4	13.8	10.3
Hacienda	8.9	9.9	12.2	15	18.3	21.2	23.3	23.1	21.2	18.1	14	10.5
Warm Springs Dam	12.5	12	12.8	12.9	13	13.2	13.3	13.1	13	12.8	12.8	12.7
Lower Dry Creek	10.3	10.9	13	14.7	16.7	17.6	17.7	17	16.2	15	13.1	11.6

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	9.3	9.4	11.4	13.2	14.7	15.3	15.8	18.1	19.9	19	15	10.9
Hopland	9.6	9.6	11.8	14.4	16.5	17.9	18.7	20.1	20.4	18.6	14.6	10.9
Cloverdale	9.6	9.7	11.9	14.7	17.2	18.9	19.9	20.7	20.1	18.3	14.5	10.7
Healdsburg	9.4	10	12.7	16.1	19.3	21.6	23.7	23	21.4	18.5	13.9	10.1
Below Dry Creek	9.8	10.2	12.8	16	18.8	19.6	19.6	19	18.3	16.7	13.5	10.2
Hacienda	9.6	9.9	12.1	15	18.4	21	22.7	21.9	20.5	18	13.6	10.4
Warm Springs Dam	12.7	12.7	12.8	13	13.2	13.2	13.1	13	13	12.9	12.8	12.7
Lower Dry Creek	11.2	11.2	12.9	15.4	17.1	16.8	16.6	16.2	15.6	14.7	13	11.4

October, this water warms as it moves downstream, with the highest predicted temperatures being 18.3°C in July under *all* water supply conditions and 17.9°C in June under *dry* water supply conditions. Water temperatures during July through September at the downstream end of Dry Creek are generally 0.7°C to 0.9°C cooler during *dry* water supply conditions than during *all* water supply conditions, due to higher release flows.

3.4.5.2 Buildout Demand Levels

Under buildout demand levels under both *all* and *dry* water supply conditions, water temperatures in the upper and middle Russian River are generally quite similar to those under current demand levels during all months. This is because the additional water needed to meet the increased demand is drawn from Lake Sonoma. Below the confluence of Dry Creek, water temperatures are 0.5°C to 1.7°C cooler than under current demand levels from July through September for both water supply conditions. At Hacienda, temperatures are again similar to those under current demand levels under *all* water supply conditions, ranging from 18.1°C to 23.3°C. Under dry water supply conditions, water temperatures at Hacienda remain 0.5°C to 0.8°C cooler during June through September under buildout demand levels than were predicted based on current demand levels.

Under the buildout demand levels in Dry Creek under both water supply conditions, water temperatures below Warm Springs Dam are similar to those under current demand levels. In the lower portion of Dry Creek, water temperatures are up to 0.9°C cooler during July and August than under current demand levels and *all* water supply conditions, ranging from 17°C to 17.7°C. In *dry* water supply conditions, water temperatures during June through October range from 14.7°C to 16.8°C, about 0.4°C to 1.1°C cooler than under current demand levels.

3.4.6 Effects of D1610 Flows on Listed Salmonids

A summary of effects is provided below. Additional discussion of the effects of D1610 operations are provided in Section 5.3 of this report. The results below are provided by lifestages for all three species. Generally, these lifestages occur during the same portions of the year, but some notable exceptions do occur and these are discussed separately.

The operations of Lake Mendocino and Lake Sonoma generally store water in the winter and augment flows in the summer. In most years, these operations generally result in only small changes during the wet winter period when many important life-history activities occur, such as upstream passage, spawning, incubation, and downstream passage of salmonids. Flows during the summer period are augmented by water supply deliveries. Under the D1610 at the projected buildout demand levels, Coyote Valley Dam flow releases remain similar to those under current demand levels under *all* water supply conditions, but are somewhat higher under *dry* water supply conditions. Under buildout demand levels, flows in Dry Creek are substantially increased from June through October under both *all* and *dry* water supply conditions.

In general, water temperature is usually good to excellent for salmonids from November through April. Summer and fall have high water temperatures that may be sub-optimal, particularly in the middle and lower Russian River. The upper Russian River generally has good temperature conditions even during the summer period. During the summer months, water temperatures in Dry Creek are markedly better than those in the Russian River and are generally at optimal or slightly cooler than optimal levels near Warm Springs Dam.

Upstream Passage

Flows under D1610 at current demand levels are generally suitable for upstream passage throughout the Russian River and Dry Creek under *all* water supply conditions. Under *dry* water supply conditions, upstream passage for coho and Chinook salmon may be impaired about a third of the time due to low flows. The model results showed the impairment extending through most of the migration season for coho and Chinook salmon. Steelhead migrate later in the season and had poor passage conditions approximately 25 percent of the time, mostly in January. During periods of impeded passage, upstream migration may be possible during and following storm events. Migration up Dry Creek appears to be unimpeded in *all* and *dry* water supply conditions.

Under the buildout demand levels, D1610 flows would be more restrictive for Chinook than under current demand levels in the early part of their migration season in *dry* water supply conditions due to the lower flows that occur in the Upper and Middle Russian River. These lower flows may extend into the early part of the coho migration season, and therefore may affect their migration opportunities as well. Flows are generally higher by December, so coho salmon would have migration opportunities in December and January, and steelhead upstream migration would be largely unaffected.

Warm water temperatures may be present during the early portion of the upstream migration season for Chinook salmon. Some Chinook salmon migrates as early as mid August. Water temperatures are stressful for adult Chinook salmon from August through October. The majority of Chinook migrate in November (Chase 2000, 2001). Later, between December through February, water temperatures are at near optimal levels for upstream migration. Coho salmon have a peak migration period during the time when water temperatures are more acceptable. Steelhead migrate upstream later in the season, and therefore experience cooler water temperatures which are near optimal for this lifestage. Water temperatures for D1610 at buildout demand levels were similar to those at current demand.

Spawning and Incubation

Spawning and egg incubation generally occurs from November through May, with the exact timing depending on the species. The peak of coho and Chinook salmon spawning occurs in November and December, while the peak of steelhead spawning occurs in February or March. Steelhead and Chinook spawn in the mainstem in the Middle and Upper reaches of the Russian River (although steelhead rely primarily on tributaries for spawning and rearing), and all three species spawn in Dry Creek. Flows under both *all* and *dry* water supply conditions appear to provide suitable habitat for spawning and incubation of steelhead and Chinook salmon in the Middle and Upper reaches of the mainstem.

Flow conditions in Dry Creek for spawning and incubation are very stable regardless of the water supply condition. These life-history activities do well under stable flow conditions. Dry Creek provides suitable spawning and incubation habitat for all three species under current demand levels. Under buildout demand levels, flows in Dry Creek under *all* water supply conditions and *dry* water supply conditions provide similar spawning and incubation conditions.

Under current demand levels, water temperatures in the mainstem are generally good for Chinook salmon and steelhead spawning and incubation. However, temperatures may become stressful for steelhead during the latter part of their incubation season (April and May) in the Middle Reach. Temperatures are generally suitable for spawning and incubation for all three species on Dry Creek. Under buildout demand levels, temperatures remained largely unchanged from those under current demand levels.

Rearing

Under current demand levels, water velocities in the Upper and Middle Reaches are higher than optimal for rearing salmonids. Optimal conditions occur only 30 to 50 percent of the time. The lower mainstem is not thought to provide substantial rearing habitat during the summer months for these salmonids due to poor habitat conditions and high water temperatures. Under *dry* water supply conditions, flows are lower resulting in improved rearing conditions. At buildout, rearing conditions are similar to those under current demand, with improved habitat in *dry* water supply conditions.

Under current demand levels, summer flows in Dry Creek can be too high for good rearing habitat. The higher flows under *dry* water supply conditions provide poor rearing conditions for all three salmonid. Under buildout demand levels, flows in Dry Creek would be also be increased over flows under current demand levels. This would increase velocities to very unsuitable levels during most of the summer.

Water temperatures in the Middle and Lower reaches of the Russian River are sufficiently high to reduce the potential for steelhead rearing through the summer and early fall. In the Upper reach of the Russian River Creek, temperatures are more suitable, providing good rearing conditions about 60 to 75 percent of the time. Water temperatures in Dry Creek under current demand levels are consistently very good or optimal throughout the summer for the juvenile coho salmon and steelhead rearing (juvenile Chinook salmon have emigrated by this time). Under buildout demand levels, temperatures are similar to those under current demand levels.

3.5 ESTUARY MANAGEMENT

The Russian River Estuary extends 6 to 7 miles from the river's mouth at the Pacific Ocean, near Jenner, upstream to Duncans Mills and Austin Creek in western Sonoma County (Figure 3-4). On occasion, tidal influence has occurred as far as 10 miles upstream to Monte Rio (RREITF 1994). A barrier beach (sandbar) occasionally forms naturally across the mouth of the river during the dry season (and may occasionally form during winter months), impounding water and forming a lagoon. The sandbar opens naturally when hydraulic conditions in the Russian River and Pacific Ocean change, or when it is artificially breached. When the sandbar is open, the Estuary is open to tidal mixing.

Current project operations affect the Estuary primarily in the low-flow months when minimum instream flow requirements under D1610 augment flow to the Estuary. These augmented flows result in a need for an artificial sandbar breaching program to prevent flooding of local property.

3.5.1 CURRENT CONDITIONS AND MANAGEMENT ACTIVITIES

Before SCWA conducted the current breaching program, the Sonoma County Department of Public Works would breach (i.e., open) the sandbar at the mouth of the river to prevent flooding of low-lying areas. On occasion, the sandbar was also breached by local residents. Resource managers became concerned that indiscriminate breaching of the sandbar was affecting the Estuary ecosystem. Following a study of the effects of artificial breaching (RREITF 1994), the Sonoma County Board of Supervisors adopted an Estuary Management Plan. SCWA assumed responsibility for the plan, and began implementing it along with any needed revisions based on monitoring studies. A monitoring program was initiated to evaluate the effects of breaching the sandbar during the period of 1996 to 2000 (Merritt Smith Consulting [MSC] 1997a. 1997b, 1998, 2000; SCWA 2001b).

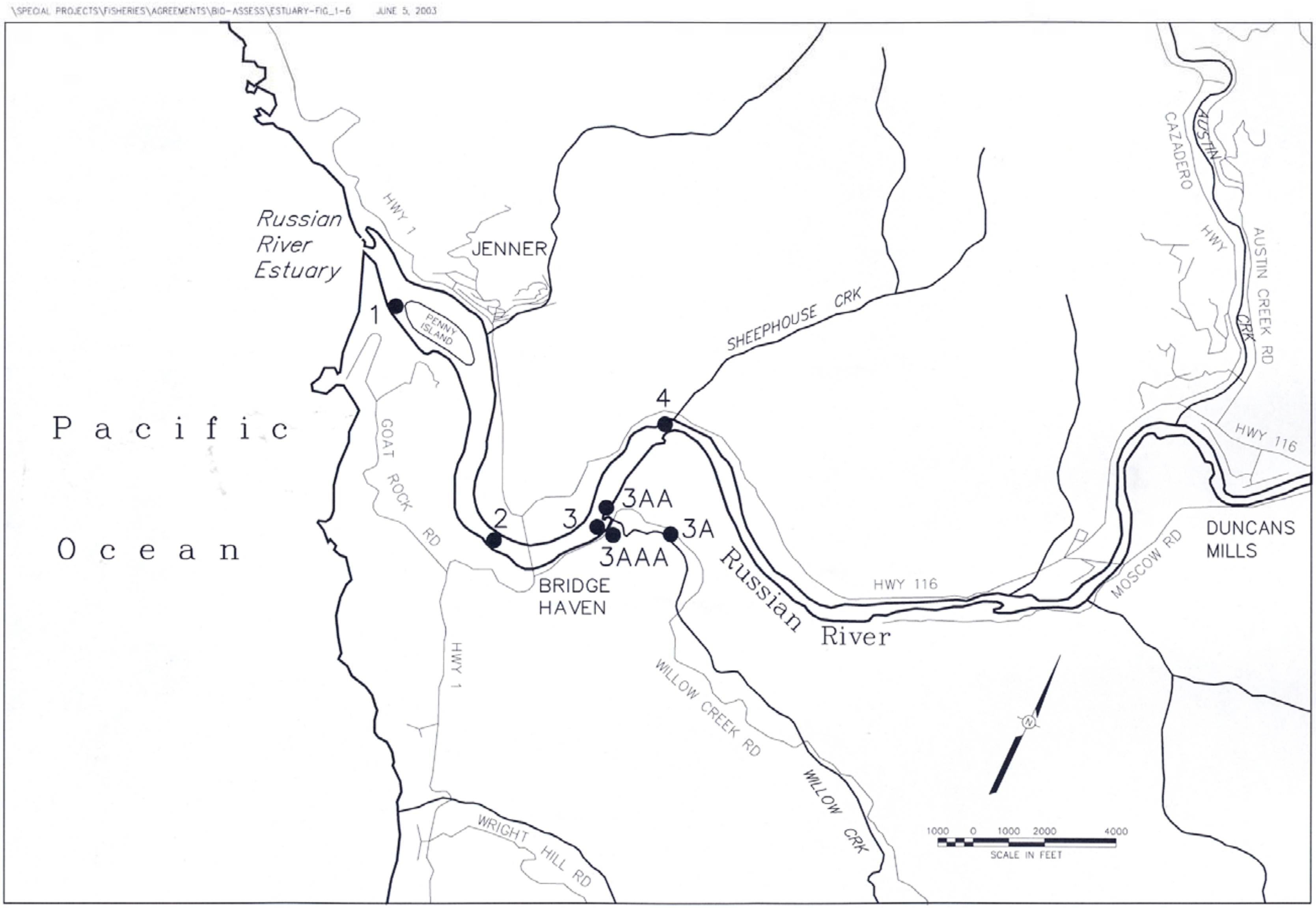

Figure 3-4 Map of Russian River Estuary Showing Biological and Water Quality Monitoring Sample Sites

The current Management Plan for the Estuary includes:

- **Breaching of the Sandbar.** The sandbar is breached when water levels in the Estuary exceed 4.5 feet at the Jenner gage. SCWA's goal is to conduct breaching before the Jenner gage measures 7.0 feet; therefore, breaching is typically conducted when water levels are between 4.5 and 7.0 feet. Water levels are determined from an automated tide recorder. The maximum water elevation was selected to minimize the discharge of anoxic water from Willow Creek Marsh into the Estuary, avoid high flushing velocities caused by high water elevations in the Estuary prior to breaching, and prevent the flooding of property. The breaching schedule varies from year to year depending on the frequency of closure of the Russian River mouth. There is no clear pattern of closures and breachings, but late summer/fall closures are typical.

- **Automated Tide Recorder.** An automated tide recorder has been installed at the Jenner Visitor's Center. Data from the tide recorder are displayed and monitored by remote telemetry at SCWA's Operations Center in Santa Rosa.

Biological and Water Quality Monitoring. Biological and water quality monitoring was conducted before, during, and after four to seven mechanical breaching events per year over a period of 5 years. Because monitoring was tied to breaching events, sandbar-open conditions that may be maintained naturally in the early part of the summer were not monitored. Data were collected at up to seven sample sites in the Estuary (Figure 3-4; Table 3-10). Water quality was also sampled at sites along Willow Creek. At each site, fish and invertebrates were sampled with a seine and otter trawl, while water temperature, DO, and salinity were measured with water quality instruments. Pinniped behavior was monitored at the Russian River mouth by visual observations.

Table 3-10 Water Quality and Fish Sampling Monitoring Locations in 1999 and 2000

Year	Water Quality	Fish Sampling
1999	Datasondes @ Stations 3, 3AA, 4 Profiles @ Stations 1, 2, 3, 3A, 3AA, 3AAA, 4	Beach seines @ Station 1, 3 Otter trawl @ Stations 1, 2, 3, 4
2000	Datasondes @ Station 3, 3A, 3AA Profiles @ Stations 1, 2, 3, 3A, 4	Beach seines @ Stations 1, 3, 4 Otter trawl @ Stations 1, 2, 3, 4

The number of breaching events varies from year to year, depending on the amount of inflow to the Estuary and beach and ocean conditions that determine the frequency of closure of the Russian River sandbar. For most of the years studied, sandbar closures and breachings were generally concentrated in the fall (Table 3-11). Under the current Estuary management, the sandbar is generally closed no more than 7 to 10 days, although it is occasionally closed for longer (MSC 2000).

Table 3-11 Summary of Sandbar Closures and Artificial Breachings, 1996 to 2000

Date Closed	Days Closed	Date Breached	Gage Height[1]	Days Open
1996				
June 29	5	July 5		
July 24	11	August 3[2]		19
August 23	5	August 27[2]		20
		September 8[2]		
September 14	12	September 26		
October 7	8	October 15		
		November 6 (N)[3]		
1997				
March 30	1	March 31		18
April 18	5	April 23 (N)[3]		12
May 2	1	May 3 (N)[3]		12
May 15	7	May 22		11
June 2	7	June 9		7
June 16	11	June 26		44
August 9	10	August 20		19
September 9	10	September 19		7
September 26	3	September 29		4
October 3	8	October 11		15
October 26	8	November 3		4
November 7				
1998				
August 26	4	September 1		6
September 7	5	September 12		1
September 13	1	September 14		9
September 23	5	September 28		7
October 5	3	October 8		7
October 15	4	October 19		4
October 23	4	October 27		1
October 28	1	November 2		
1999				
June 12[4]	3	June 15	7.4	6
June 24	6	July 1	6.3	78
September 17	7	September 23	6.6	2
September 25	8	October 4	7.0	3
October 7	14	October 15, 21[5]	6.7, 7.44	9
November 1	3	November 4(N)[3]	5.7	2
November 6	4	November 10	8.9	3
2000				
May 7	2	May 9	8.46	37
June 16	5	June 21	6.90	67
August 28	8	September 5	7.62	31
October 7	4	October 11	6.54	12
October 24	3	October 27	6.87	7
November 4	3	November 7	6.93	2

Table 3-11 Summary of Sandbar Closures and Artificial Breachings, 1996 to 2000 (Continued)

Date Closed	Days Closed	Date Breached	Gage Height[1]	Days Open
November 10	3	November 13	6.74	7
November 21	3	November 24	7.34	2
November 27	3	November 30	7.73	2
December 3	3	December 6	7.69	20
December 27	2	December 29	7.10	4

[1] Height on tide gage immediately before breaching.
[2] Unauthorized breach by unknown persons.
[3] Natural breach.
[4] Sandbar closed completely on June 12, but was partially closed for at least 9 days before that.
[5] Sandbar was breached October 15, but closed again the following day. Sandbar was breached again on October 21.

3.5.1.1 Water Quality

High water temperature in the lower mainstem Russian River has been considered a factor affecting salmonid rearing habitat. However, below RM 10, coastal fog and other marine influences have a cooling effect on surface water. The coastal river zone may provide better conditions for salmonids than the lower mainstem, including cooler summer temperatures (Winzler and Kelly 1978).

When the sandbar closes the river mouth, it traps saltwater in the lagoon. Because saltwater is denser than fresh water, it forms a layer under the fresh water from the river inflows (stratification), forming a saltwater lens that traps heat. Salinity, temperature, and DO stratification occur within the water column. Through natural processes, DO becomes depleted in the bottom saline layer and anoxic conditions develop.

This process was documented in the Estuary during the 5-year monitoring study. Water quality data were collected before, during, and after artificial breaching events at 1-meter-depth intervals in the water column at sites between the river's mouth and Sheephouse Creek. Water quality profiles were generally taken in the afternoon, so diurnal changes were not recorded.

When the sandbar closed, salinity stratification led to reductions in DO and increases in temperature in the near-bottom layers of deep pools within the first 2 weeks. When the sandbar was breached, tidal mixing contributed to a renewal of DO and reduced temperatures. This process occurred most quickly near the mouth of the river, but took up to several days at upstream sites. The rate of change was influenced by the volume of river flows, whether there was a spring tide or neap tide, and the length of time the sandbar remained open. When the sandbar re-formed, salinity stratification again led to a deterioration of water quality in deep pools.

The deepest pools often remained stratified until an influx of tidal flows or higher winter flows flushed the pools or caused mixing of the stratified layers. Summer breaching of the sandbar draws fresh water through the Estuary and accelerates mixing of stratified layers in the pools, which increases DO at depth. However, flows caused by breaching may not be sufficient to mix saline waters located at the bottom of the deepest pools.

Because the sandbar is breached frequently under the current Management Plan, the duration of low DO and high temperature conditions near the mouth of the river were generally limited to approximately 2 weeks or less. Data from 1999 show that water quality in near-bottom layers of pools was better when the sandbar was open than when it had been closed for a short period of time (2 weeks).

In a pre-breaching survey on June 30, 1999 at water quality monitoring Station 2, surface waters were 24°C; however, in the subsurface layer, with a very high DO spike (likely related to photosynthetic plants), water temperatures were cooler, between 15 and 20°C (MSC 2000). Therefore, the best fish habitat would have occurred in this subsurface layer. A survey on July 6 during tidal conditions revealed a similar temperature and salinity profile, but DO was more uniform from surface to bottom at levels between approximately 6 and 8 mg/l, increasing the portion of the water column that had suitable habitat conditions for salmonids.

At water quality monitoring Station 3 at the mouth of Willow Creek, temperatures in the near-bottom layer of the monitored pool were suitable when the sandbar was open, and DO levels fluctuated, generally increasing during spring tides and decreasing during neap tides (MSC 2000). After the sandbar closed on October 7, 1999, DO decreased steadily from 6 to 7 parts per million (ppm) during a 14-day closure, and anoxia was reestablished in the bottom layers of the pool by October 18 (within 11 days). During two brief November closures (3 and 4 days long), DO levels declined, from approximately 5 ppm to very low levels, but anoxic conditions did not form in the near-bottom layer.

In contrast, at water quality monitoring Station 4, the most upstream monitoring site, near-bottom anoxia was not relieved until 5 days after a June 15 breaching. This occurred during neap tides at a river flow of 260 cfs. When the sandbar closed on June 24, near-bottom DO gradually declined during a 6-day closure, and continued to decline for several days after the July 1 breaching. Highest DO values were usually associated with spring tides (MSC 2000).

Salinity levels of approximately 30 ppt have been recorded as far upstream as Sheephouse Creek, approximately 3.1 miles upstream of the river mouth. Salinity at this level is similar to ocean water.

This study only monitored water quality during short periods of sandbar closure. If the lagoon were to stay closed and there was sufficient freshwater inflow, the lagoon would be expected to convert to fresh water, water quality would improve, and fluctuations in habitat conditions would be eliminated.

Datasondes (instruments used to record hourly temperature, salinity, and DO) were deployed on the bottom of deep pools in the Estuary and in Willow Creek throughout the study season to characterize water quality through the summer (Figure 3-4). The data show that, when the sandbar remains open, water quality is generally better in the near-bottom layers than when it has been closed for a short time (MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). It should be noted that datasonde monitoring may give a general assessment of water quality changes in these deep pools, but does not assess the extent of microhabitat elsewhere that may provide refugia for salmonids.

Water quality is affected by the schedule of artificial breaching, but is not completely determined by it. The renewal of DO in the saline near-bottom layers of deep pools is mediated by both river flow and tidal action (spring/neap cycle) as well as by post-breaching flushing (MSC 2000). While low DO in the near-bottom layers of the deep pools is associated with sandbar-closed conditions, anoxia can also develop under tidal conditions during neap tides and/or low river flows (MSC 2000).

3.5.1.2 Biological Resources

A total of 43 species of fish were collected in the Estuary during the 5 years of the monitoring study (MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Commonly captured estuarine/marine species included topsmelt, Pacific sanddab, starry flounder, staghorn sculpin, prickly sculpin, threespine stickleback, and shiner surf perch (see Table 2-6). The distribution of marine fish is limited to the lower Estuary below the Willow Creek mouth, with the most salt-tolerant species found only near the Russian River mouth.

Commonly captured freshwater fish included Sacramento sucker, Sacramento pikeminnow, and California roach. These species tend to move down into the Estuary during the summer and return upstream in the fall. Macroinvertebrate species commonly captured in otter trawls included opossum shrimp (*Neomysis mercedis),* bay shrimp (*Crangon franciscorum*), dungeness crab (*Cancer magister*), amphipods (*Eogammarus confervicolus*), and spaeromatid isopods (SCWA 2001b).

The upper portions of the Estuary (Duncans Mills to Sheephouse Creek), which have not been sampled, are important for juvenile-rearing salmonids, especially because the coastal fog belt moderates high water temperatures in the summer. Data from the Mirabel sampling program indicate that naturally-spawned juvenile Chinook salmon migrate down the Russian River in the spring (Chase et al. 2000). Fall-run Chinook have been known to rear in estuaries before migrating to the ocean (Kjelson et al. 1982), and may rear for a time in some part of the Estuary. The tributaries in the lower Russian River contain high-quality steelhead spawning and rearing habitat. Although steelhead rear in fresh water throughout the year, they have been caught in the Estuary and may make use of suitable portions of the Estuary (MSC 2000).

Biological sampling, which has been conducted around artificial breaching events, has been largely concentrated in fall months, and therefore was not designed to assess how salmonids may use the Estuary throughout the year. In 1997, when fish sampling occurred earlier in the year, steelhead were captured throughout the summer, and 3-year classes appeared to be represented (MSC 1997a). Steelhead were captured during all 5 years sampled. Chinook salmon were captured in 1992, 1993, 1997, and 1999 in the early spring when migration occurs (RREITF 1994; SCWA 2001b). Coho salmon also pass through the Estuary, but have not been captured during sampling for the Management Plan. Most adult salmonids migrate up the Russian River during the period when the mouth is naturally open, usually late fall to early spring.

Pinnipeds use the sandspit at the river mouth as a haulout and to forage for fish, which may include listed salmonids. Harbor seals, sometimes numbering in the hundreds, regularly use the Russian River mouth year-round, while California sea lions and elephant seals occur periodically in low numbers. Harbor seal numbers peak in the late winter and mid-summer and prefer to use the river’s mouth when it is open.

The capture rate of salmonids by seals may be affected by the width of the breach opening and river flows during fish migration periods. A mechanical breach with a wide opening and ample flows increases passage for outmigrating juveniles and returning adults through the river mouth, and may reduce the potential for seals to capture salmonids. Seals have been observed foraging in the Estuary, and are more successful at capturing fast-moving prey, such as salmonids, if they can take advantage of trapped or stressed fish. In 1992, outmigrating juvenile salmonids consisted of 17 percent of the prey items of harbor seals when the mouth was closed, compared with 5 percent when the Estuary was open (RREITF 1994). However, this predation rate may not have been representative of typical conditions. Prior to the predation study, rainfall had increased flows in the Russian River, the sandbar and the river mouth had closed the Estuary, and 36,000 salmonid smolts were released from the DCFH upstream of the Estuary. Since this time, smolts are released from DCFH between December and April over a 3-day period during new moon phases, with the majority of fish being in February and March. The Estuary is generally open during this time.

3.5.1.3 Willow Creek

In 1992, a fish (prickly sculpin) and invertebrate (mysid) kill at the mouth of Willow Creek was associated with a flush of anoxic water from Willow Creek following a sandbar breach after water levels reached over 9 feet (RREITF 1994). This type of event has not occurred during the 5 years of monitoring the Estuary. Mortality of prickly sculpin in 1998, associated with a breaching event after water levels rose to 8.2 feet, may have been caused by low DO in water draining from Willow Creek, but no anoxia was detected (MSC 1998). Dead dungeness crabs were found in 1999 near the mouth of Willow Creek, but this was most likely due to a flush of fresh water after an artificial breaching event (MSC 2000).

The 1992 and 1998 high-mortality events were associated with breaching that occurred at over 9.0 feet and 8.2 feet, respectively. Artificial breaching associated with water levels lower than 8.0 feet did not result in similar events. When water levels were greater than 8 feet, near-bottom DO levels at the monitoring sites became anoxic within a few days of sandbar closure. Currently, artificial breaching is initiated when the water level reaches 7 feet at the Jenner gage, to reduce the risk of flushing anoxic water from Willow Creek.

The 1992 event was believed to occur because a large area of Willow Creek marsh was inundated and then became anoxic due to low water inflow and high biological oxygen demand (BOD) (RREITF 1994). Another explanation could be that, when the sandbar is breached at higher water surface elevations, higher flushing flows are more likely to discharge bottom waters, and sediments containing low DO levels.

3.5.2 Factors Affecting Species Environment within the Estuary

The Estuary is important for adult and juvenile passage for all three listed species. When juvenile salmonids become smolts, they undergo a physiological change that allows them to make a transition from fresh water to salt water. An estuary provides an opportunity for smolts to gradually become acclimated to ocean conditions before their migration out of the river system. Estuaries and lagoons can also provide important rearing habitat for steelhead and Chinook salmon, and possibly for coho salmon.

Under D1610 flow conditions, the system is generally managed as an estuary (sandbar open) rather than a lagoon (sandbar closed), to prevent flooding of local property. Augmented summer flows have the potential to affect several components of salmonid habitat in the Estuary. These include water quality (including temperature, DO, and salinity), primary productivity and the availability of aquatic invertebrates, availability of shallow-water habitat, and the concentration of nutrients and toxic runoff. The breaching program directly affects these components.

The artificial breaching program has the potential to affect adult salmonid upstream migration and juvenile downstream migration by creating additional passage opportunities. Since adult Chinook salmon congregate at the mouth of the river as early as late August, artificial breaching is of particular concern for this species. If the sandbar is breached before rising river flow from winter storms improves water quality in the mainstem Russian River, adult Chinook salmon may become trapped in poor quality water. The risk of predation on listed fish species may be slightly increased when migrating juvenile salmonids are concentrated into a channel through the sandbar, and when pinnipeds are attracted to the breached sandbar.

Estuaries and coastal lagoons have been found to provide important salmonid rearing habitat in coastal lagoons in the southern portion of the CCC steelhead ESU (Smith 1990) and elsewhere (Larson 1987; Anderson 1995, 1998, 1999; Reimers 1973). If the sandbar of one of these central California estuaries remains open, good water quality can be maintained with tidal mixing or high river flows. In a lagoon (sandbar closed), water quality initially decreases in the short-term, but suitable water quality develops when the system is converted to fresh water, which results in lower water temperatures and higher bottom-DO levels. Some of the best rearing habitat can develop under these conditions (Smith 1990). Infrequent breaching of these lagoons, particularly during low-flow summer months, impairs water quality because, each time the sandbar reforms, there is a long transition period with salinity stratification, which results in high water temperatures and low DO levels (Smith 1990). If summer inflow to the lagoon is low, the lagoon may not freshen again for the remainder of the season. After the sandbar opens, there is a period of rapid transition when habitat and water quality changes dramatically. After these transition periods, the flora and fauna of the estuary undergo dramatic changes in response to the changed environment.

Rapid or fluctuating changes in salinity and water level in small coastal lagoons can have substantial effects on the invertebrate foodbase for fish. Smith (1990) found that when sandbar formation resulted in anoxic conditions over the majority of the substrate, amphipods were eliminated from those areas, and invertebrate populations crashed as the lagoons went through the transition to fresh water. Once these lagoons had converted to freshwater conditions, invertebrate populations became sufficiently re-established to result in accelerated salmonid growth. Continuous breaching, such as occurred at San Gregorio lagoon in the summer of 1986, resulted in low overall invertebrate populations as the system fluctuated between anoxic saline and freshwater conditions.

Sandbar breaching may also influence habitat and water quality in Willow Creek marsh. Water quality monitoring showed that DO in the marsh decreased following sandbar closure, possibly because terrestrial vegetation becomes submerged and begins to decay, increasing BOD during a time when water flow into the marsh is insufficient to renew DO levels. Fluctuating water levels may create conditions that are different from those that would be found in a stable marsh, where aquatic vegetation has time to establish and renew DO in the wetted portions of the marsh.

Augmented flow in the Russian River Estuary has several beneficial effects. It may slow the development of poor water temperatures and DO levels after the sandbar closes. Agricultural and urban runoff from the watershed may increase nutrient loads and chemical levels in the Estuary. Augmented summer flows help to dilute these constituents and carry them out of the Estuary when it is open.

The present need to breach the Estuary in the dry season reduces the value of the Estuary for rearing. Summertime breaching causes repeated changes in habitat conditions (depth, salinity, temperature, and DO) in the Estuary that reduce the beneficial effects. While salmonids are highly mobile and can move away from these areas, most of their foodbase is not as mobile and may experience population fluctuations during repeated breachings. The reduction of this foodbase may thereby reduce the suitability of the Estuary for juvenile salmonids.

3.6 CHANNEL MAINTENANCE

SCWA conducts channel maintenance activities in the Russian River and its tributaries for the purposes of flood and erosion control. The locations of channel maintenance areas on the Russian River are shown in Figure 3-5. SCWA's scope of responsibilities in the Sonoma County portion of the Russian River watershed include activities related to the Central Sonoma Watershed Project and the Mark West Creek watershed, portions of various channels near the cities of Healdsburg, Windsor, Santa Rosa, Pohnert Park, Cotati, and Sebastopol; and USACE dams on the East Fork Russian River (Coyote Valley Dam) and Dry Creek (Warm Springs Dam).

The activities implemented by SCWA for flood control purposes in the Central Sonoma Watershed Project and Mark West Creek watershed include sediment removal, channel debris clearing, vegetation maintenance, and bank stabilization. The Zone 1A flood control zone is shown in Figure 3-6. SCWA channel maintenance activities include the following:

1. Channel maintenance within the Central Sonoma Watershed Project and Mark West Creek watershed.
2. Russian River
    a. Channel maintenance related to the construction and operation of Coyote Valley Dam.
    b. Channel maintenance related to USACE-identified and -constructed flood and erosion control sites (federal sites).
    c. Channel maintenance related to Public Law 84-99 sites (nonfederal sites).
    d. Debris removal as necessary to protect life and property.
3. Dry Creek channel maintenance related to the construction and operation of Warm Springs Dam (federal sites) and inspection of one nonfederal site (Public Law 84-99).
4. NPDES stormwater discharge permit activities in the Santa Rosa area.

MCRRFCD conducts channel maintenance activities related to the CVDP in the Mendocino County portion of the Russian River. This includes channel maintenance related to federal sites and inspection of Public Law 84-99 (nonfederal) sites. MCRRFCD also conducts activities related to streambank erosion control in the Russian River.

3.6.1 Central Sonoma Watershed Project

In addition to constructed flood control channels (discussed in the following section), the Central Sonoma Watershed Project includes four flood control reservoirs built in the late 1960s to reduce flooding in the Santa Rosa area. These four flood control reservoirs are located on Santa Rosa, Brush, Paulin, and Matanzas creeks. The Santa Rosa Creek Reservoir (Spring Lake) is located offstream. A diversion structure at the inlet allows relatively low flows to bypass the reservoir, routing the flow downstream into Santa Rosa Creek, while a portion of the higher flows are diverted into the reservoir. A diversion structure on Spring Creek also diverts water to Spring Lake. Spring Lake drains back to Santa Rosa Creek through a stand pipe when water levels become too high. Other than the Santa Rosa Creek Reservoir, the other flood control reservoirs are situated onstream and are equipped with facilities (low-flow bypass and principal spillway) that allow minimum streamflows to be released. These reservoirs operate passively and are not equipped with flood control gates.

Facilities are not provided for anadromous fish passage above the instream flood control reservoirs or the diversion on Spring Creek. However, a fish ladder and vortex weir are located on Santa Rosa Creek to assist anadromous fish passage.

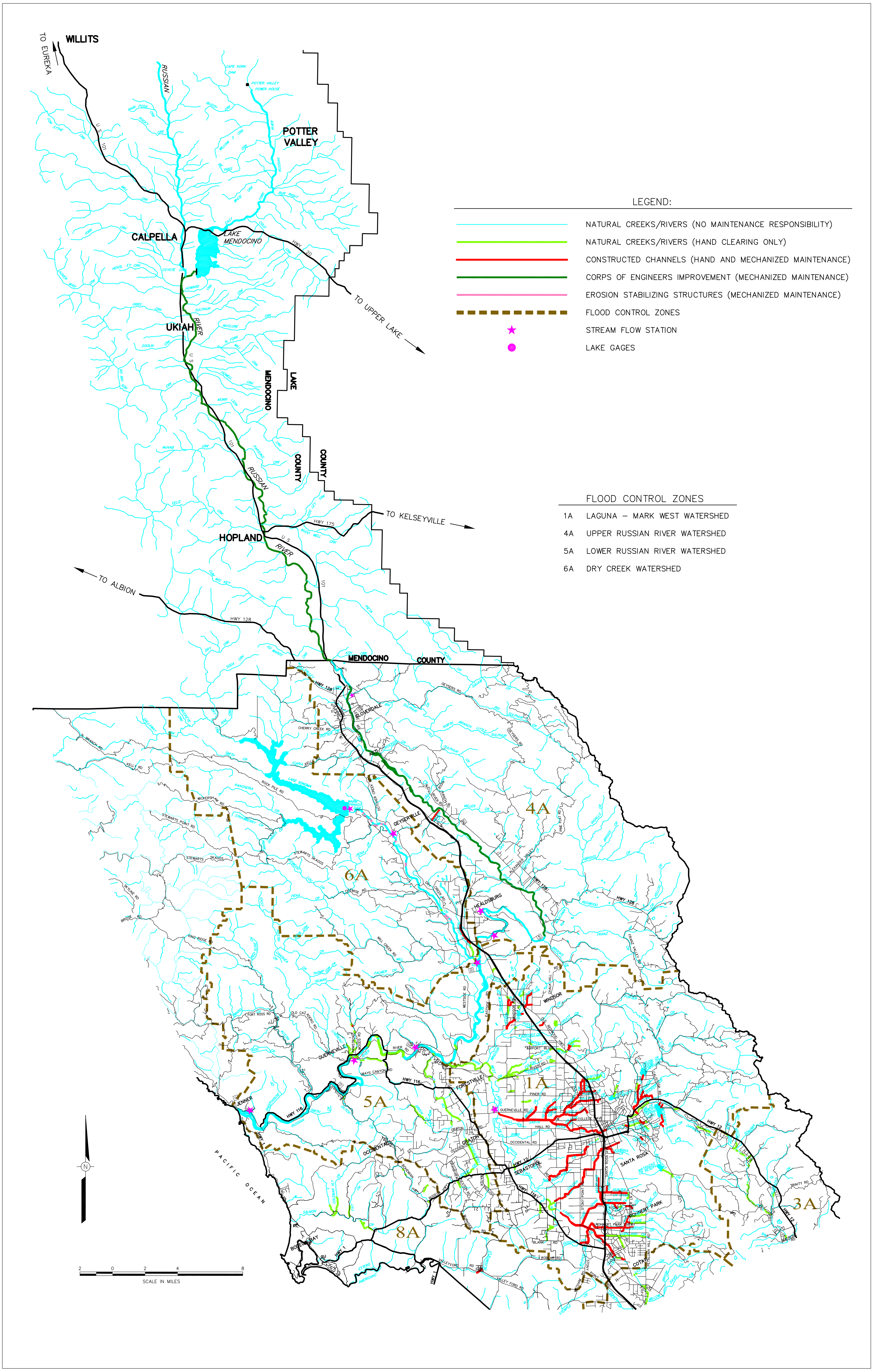

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Figure 3-5 Channel Maintenance Areas of the Russian River Watershed

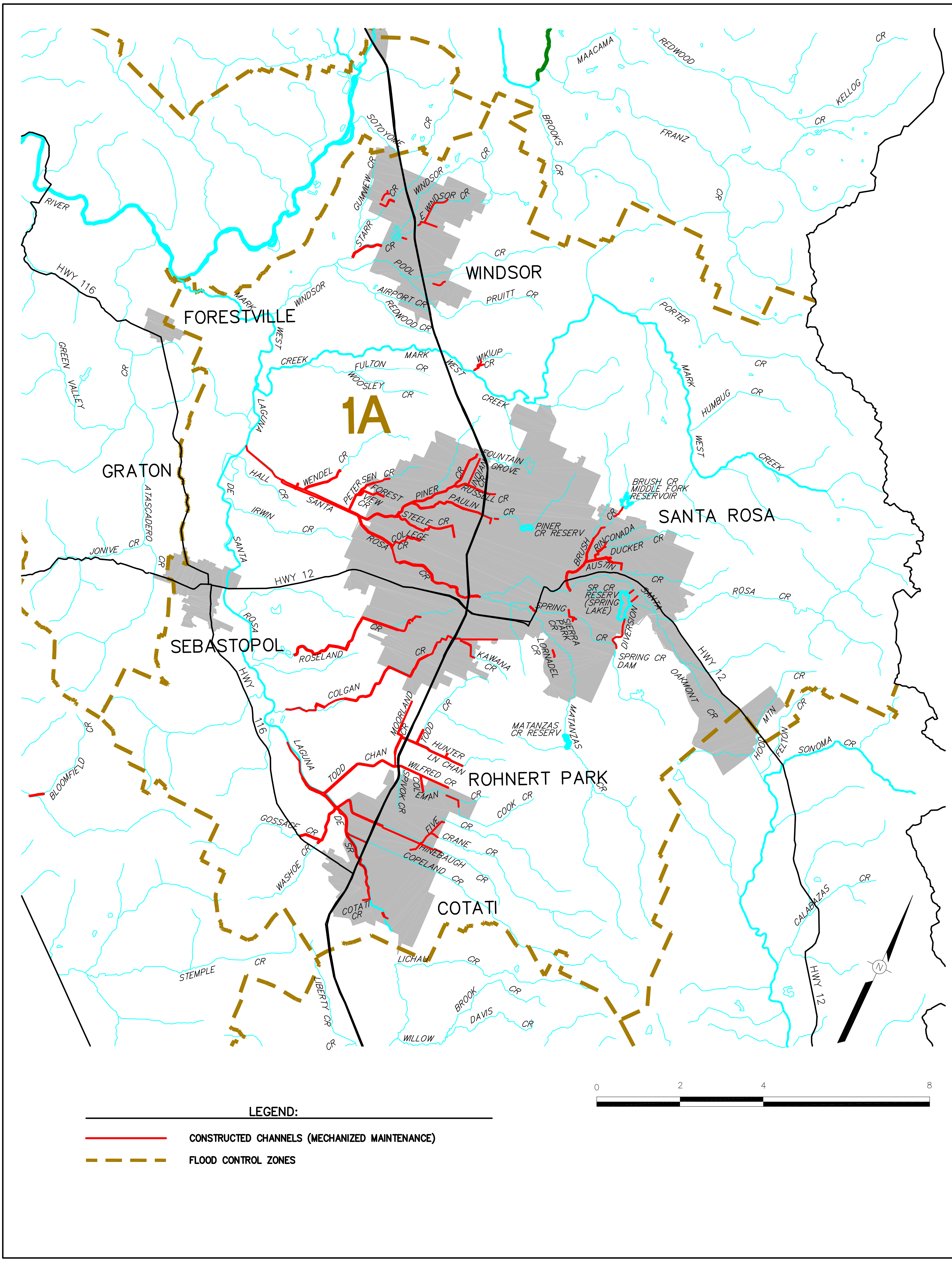

Figure 3-6 Zone 1A Constructed Flood Control Channels

3.6.2 Natural Waterways and Constructed Flood Control Channels Maintained in the Russian River Watershed

SCWA conducts channel maintenance activities on approximately 300 miles of creeks within Sonoma County. Most of these streams are located in the Russian River watershed. The creeks include both natural waterways and constructed flood control channels.

Channel maintenance activities for these channels are discussed in this section. Channel maintenance activities related to the Coyote Valley Dam and Warm Springs Dam projects in the Russian River and Dry Creek are discussed in the following section.

3.6.2.1 Constructed Flood Control Channels

Constructed flood control channels (many of which are part of the Central Sonoma Watershed Project) are widened and straightened waterways that have been significantly altered and improved based on flood control criteria (Table 3-12). The purpose of the

Table 3-12 Constructed Flood Control Channels (Portions Thereof) Maintained by SCWA in the Russian River Watershed

Airport Creek	Forestview Creek	Paulin Creek	Starr Creek
Austin Creek	Gird Creek	Peterson Creek	Steele Creek
Brush Creek	Gossage Creek	Piner Creek	Todd Creek
Coleman Creek	Hinebaugh Creek	Redwood Creek	Washoe Creek
Colgan Creek	Hunter Lane Channel	Rinconada Creek	Wendell Creek
College Creek	Indian Creek	Roseland Creek	Wikiup Creek
Cook Creek Sediment Basin	Kawana Creek	Russell Creek	Wilfred Creek
Copeland Creek	Laguna de Santa Rosa	Santa Rosa Creek	Windsor Creek
Ducker Creek	Lornadell Creek	Sierra Creek	Woods Creek
Faught Creek	Norton Slough	Spivok Creek	
Five Creek	Oakmont Creek	Spring Creek	

improvements is to increase hydraulic capacity. SCWA either owns in fee the rights-of-way for constructed flood control channels, or holds a drainage easement on them. These channels generally include service roads to facilitate maintenance access.

Sediment removal was historically performed on an annual basis in the constructed flood control channels. Sediment removal is now conducted on an as-needed basis. Some of the constructed flood control channels require annual sediment removal, some require sediment removal approximately every 2 to 5 years, and some have never required sediment removal. Recent sediment removal activities on flood control channels have included Copeland, Colgan, Russell, Todd, Indian, Hinebaugh, and Roseland creeks, as well as the Cook Creek sediment basin.

SCWA performs routine vegetation maintenance for flood control purposes on approximately 150 miles of constructed flood control channels in Sonoma County. The access roads for these channels were historically kept clear of vegetation through the use of residual herbicides, which are effective for an extended period of time. Since the early 1990s, access roads have been cleared with aquatic contact herbicides (which are effective only at the time of application [i.e., early spring]) and mowing.

Historically, SCWA was required to limit all vegetation on streambanks to predominately grass, with little or no tree growth. This represents baseline conditions. Since coho salmon were listed under the ESA, vegetation maintenance practices have been more limited.

Historically, the upper third of the channel bank was mowed to remove all grasses, bushes, and small trees. Since 1996, some vegetation has been allowed to develop and existing trees are maintained. Maintenance of the middle third of the channel bank has typically been limited to debris removal and light thinning of willow growth, as necessary.

Vegetation maintenance on the lower third of the channel, including the toe of the channel, was historically conducted annually. Recently, vegetation removal along the lower third of the bank has been less frequently performed and is more selective, leaving some widely-spaced woody riparian growth, but preventing dense vegetation.

The original design of these channels assumed that the 100-year-flood capacity[5] could be maintained by keeping these channels free of sediment and most vegetation, except for grasses. A hydraulic assessment of selected Zone 1A constructed flood control channels (Figure 3-6) was performed in 2000 to quantify flood capacity under baseline vegetation management scenarios. Flood capacity under various vegetation maintenance practices were also modeled (ENTRIX, Inc. 2002a) using USACE HEC-RAS. This assessment evaluated the channel maintenance needed to ensure that the design flow, typically a 100-year recurrence interval discharge (for drainage areas greater than 4 mi^2), can be safely passed. It should be noted that sediment deposition is another factor that can diminish hydraulic capacity, but this was not included as part of the model simulations, so interpretation of the results are based only on the influence of vegetation. Furthermore, not all channels were modeled, and hydraulic capacity of channels can only be definitively determined on a case-by-case basis.[6] However, most channels were originally designed with the expectation that there would be adequate flood capacity if vegetation were maintained primarily as grasses.

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[5] Design capacity for flood control channels is based on a sliding scale determined by the size of the area drained. For areas greater than 4 square miles (sq mi), channels were designed to pass the 100-year event, For areas between 1 sq mi and 4 sq mi, channels were designed to pass the 25-year event, and for areas less than 1 sq mi, channels were designed to pass the 10-year event.

[6] Hydraulic modeling was conducted on portions of streams that represent a range of channel types, including Hinebaugh, Santa Rosa, Colgan, Five, Piner, and Brush creeks.

The following four vegetation maintenance scenarios were evaluated:

> *Original Design.* To maintain the 100-year flood (i.e., the design flow), it is assumed that only low grass exists on the banks, that no shrubs or trees are present, and that the channel bed is vegetation free. This represents the baseline condition upon which the channel designs were originally developed.
>
> *No Maintenance.* This scenario assumes full development of mature vegetation on the bed and banks, and the presence of dense woody vegetation, tall weeds, willows, shrubs, and trees. This scenario also assumes encroachment of vegetation from banks into the channel and dense aquatic vegetation on the bed. This condition would exist on many of the constructed flood control channels if all vegetation maintenance activities were to cease for at least 15 years.
>
> *Post-Maintenance.* The bottom 5 feet of bank above the channel bed has no more than 2 year's worth of growth, allowing only scattered small shrubs and young willows (less than 5 feet tall). The rest of the bank above 5 feet from the channel bed is subject to thinning to prevent dense understory of willows, blackberries, and other shrubs. Existing mature trees are not removed, and banks may become moderately well-vegetated. The channel bed is in near-original design condition; however, some encroachment of vegetation from banks and aquatic vegetation, primarily tules and grasses, establishes initially (up to 2 years of growth).
>
> *Pre-Maintenance.* This scenario describes the channel condition just prior to the post-maintenance activities. It assumes a 5-year cycle between the post-maintenance work periods, and thus 5 years of vegetative growth on the bed and banks. The bottom 5 feet of bank above the channel bed will be expected to have moderately dense shrubs and many willows over 5 feet high. The rest of the bank height above 5 feet will have developed slightly more dense vegetation than in the post-maintenance scenario. The channel bed is also expected to have 5 years of growth that allows tules, grasses, and a few scattered young willows to establish. However, observations indicate that streams with active flow during the summer period will maintain most of the channel bed free from dense vegetative growth (willows are unlikely to establish in standing water.)

This hydraulic assessment suggests that, other than Five Creek and possibly the few high-gradient, high-width depth ratio channels (for example Hinebaugh Creek upstream of Highway 101), most channels need aggressive maintenance activities to keep vegetation from growing into a dense brushy stage to provide 100-year-flood capacity. Table 3-13 provides a brief summary of findings from the hydraulic assessment.

Table 3-13 Summary of Findings, Hydraulic Assessment of Zone 1A Constructed Flood Control Channels under Various Maintenance Scenarios

Maintenance Scenario	Sufficient Capacity	Creek Evaluated
Original Design		
100-year flood	No	Santa Rosa Creek downstream of Willowside Bridge, Hinebaugh Creek Laguna de Santa Rosa confluence to near La Bath Bridge (4,000 feet), and one segment of Colgan Creek.
	Yes	All other channels evaluated in this analysis.
10-year flood	No	Santa Rosa Creek downstream of Willowside Bridge.
No Maintenance		
100-year flood	Yes	Five Creek from Hinebaugh Creek channel to Snyder Lane, Hinebaugh Creek from upstream of Snyder Lane downstream to Hinebaugh Interception channel (3,000 feet), and a few high-gradient, high width depth ratio channels.
	No	All other channels evaluated in this analysis.
Post-Maintenance		
100-year flood	Yes	Almost all segments of Santa Rosa, Piner, and Hinebaugh creeks.
	No	Lowest segment of Hinebaugh Creek, and several short segments of Santa Rosa, Piner, and Hinebaugh creeks.
25-year flood	Yes	Santa Rosa, Piner, and Hinebaugh creeks.
Pre-Maintenance		
100-year flood	Yes	Hinebaugh Creek upstream of Highway 101 Bridge, and Five Creek.
	No	All other channels evaluated, including Santa Rosa Creek and Piner Creek downstream of Highway 101.

The post-maintenance scenario, which describes vegetation management practices in the 1990s, provides 100-year-flood capacity in most of Santa Rosa, Piner, and Hinebaugh creeks, but not always with sufficient freeboard. Therefore, site-specific areas may require vegetation maintenance that maintains original design capacity (baseline). Because 100-year flows are not contained in Santa Rosa Creek under the pre-maintenance scenarios, it will likely be necessary to perform maintenance more frequently than on the 5-year cycle modeled, or to maintain the original design capacity. Santa Rosa Creek downstream of the Willowside Road Bridge was the only channel segment with insufficient original design capacity to accommodate even the 10-year flood event. Only in Five Creek, and a portion of Hinebaugh Creek, will the pre-maintenance scenario provide capacity for the 100-year flow.

Except for a handful of bridges and culverts, most were capable of passing the 100-year discharge under pre- and post-maintenance scenarios. The culvert at Snyder Lane in Hinebaugh Creek appears to be the only location that cannot pass the 100-year flow under the original design and meet SCWA criteria for freeboard. The following bridges do not have the capacity to pass the 100-year discharge under either the pre- or post-maintenance scenarios, or both, and require the original design maintenance scenario.

Santa Rosa Creek	Stony Point Bridge: pre- and post-maintenance Willowside Bridge: pre-maintenance
Piner Creek	Hopper Ave. culvert: pre- and post-maintenance
	Fulton Road Bridge: pre- and post-maintenance
Hinebaugh Creek	Snyder Lane: original, and pre- and post-maintenance Redwood Ave. culvert: pre- and post-maintenance

A recent USACE study for the Santa Rosa Creek watershed that updates and re-evaluates rainfall and runoff conditions indicates that flood flows are of a higher magnitude than has been historically calculated and used to design flood control facilities (USACE 2002a & b). SCWA is currently developing a more detailed study to evaluate the hydrology of the watershed and the hydraulic capacity of the flood control channels by examining and verifying several of the assumptions in USACE analysis. This study is part of the Santa Rosa Creek Ecosystem and Flood Damage Reduction Feasibility Study (USACE 2002b).

3.6.2.2 Natural Waterways

Natural waterways are those that have not been modified for flood control purposes by SCWA or USACE. SCWA holds permissive channel-clearing easements on many natural waterways in the Russian River watershed (Table 3-14).

Sediment removal is not routinely performed on natural waterways. Occasionally, sediment and debris removal is conducted on natural waterways in response to an event such as a large storm. In recent years, this has included Austin and Big Sulphur creeks. These activities have been treated as emergency repairs. Based on past history, such activities occur once every 5 to 10 years.

Table 3-14 Natural Waterways (Portions Thereof) Historically Maintained by SCWA in the Russian River Watershed

Atascadero Creek	Fife Creek	Laguna de Santa Rosa	Roseland Creek
Barlow Creek	Forestville Creek	Libreau Creek	Santa Rosa Creek
Blucher Creek	Foss Creek	Lower Russian River	Sheephouse Creek
Burton Ditch	Fountain Grove Creek	Mark West Creek	Spring Creek
Calder Creek	Fulton Creek	Matanzas Creek	Starr Creek
Coleman Creek	Green Valley Creek	Norton Slough	Steele Creek
Colgan Creek	Hartman Creek	Olivet Creek	Wikiup Creek
Copeland Creek	Hessel Creek	Paulin Creek	Wilfred Creek (N Fork)
Crane Creek	Hood Mountain Creek	Piner Creek	Willow Creek
Dry Creek	Hulburt Creek	Pocket Canyon Creek	Windsor Creek
Dutch Bill Creek	Jonive Creek	Rieman Creek	Woolsey Creek

Regular maintenance on natural waterways was performed historically with the objective of maximizing the hydraulic capacity without enlarging the waterways. In the 1970s to 1980s, SCWA staff used heavy equipment and hand crews with chainsaws to clear vegetation from the bottom of natural waterways. The use of heavy equipment ended in 1987, with clearing continuing to be performed by four-person crews using hand labor. Currently, no maintenance is performed unless SCWA elects to do so to protect adjacent property.

3.6.3 Channel Maintenance Related to Construction and Operation of Coyote Valley Dam and Warm Springs Dam

3.6.3.1 Coyote Valley Dam

SCWA and MCRRFCD were designated as the local agencies responsible for channel maintenance below Coyote Valley Dam following completion of the dam. USACE provided MCRRFCD and SCWA with O&M manuals for Mendocino and Sonoma counties, respectively (USACE 1965a, 1965b), and the *Water Control Manual for Coyote Valley Dam* (USACE 1986a). These manuals include procedures for operating the dam and maintaining the flood control improvements on the Russian River.

The Russian River naturally exhibits substantial meandering, erosion, and aggradation, which has caused problems near the channel maintenance sites since they were constructed. Operation and maintenance of these sites became the responsibility of local agencies after construction. Manuals provided by USACE (USACE 1965a, 1965b) have provided guidelines for inspecting and maintaining the installed improvements on a yearly basis, or as needed before, during, and after flood events.

In addition to channel improvements installed as part of the mitigation project for Coyote Valley Dam, SCWA and MCRRFCD are responsible for inspecting certain channel improvement sites that were constructed between 1956 and 1963. The sites are located at various places in Sonoma and Mendocino counties, extending from RM 98 near Calpella to approximately RM 40 near Maacama Creek in Healdsburg.

3.6.3.2 Warm Springs Dam

Channel improvements at 15 sites along Dry Creek were built by USACE between 1981 and 1989 as part of the Warm Springs Dam and Lake Sonoma Project. The improvements include three rock-type grade-control structures, 5,800 feet of riprap bank protection, and flow-deflection fences. These improvements were intended to provide bank and riverbed stabilization at sites where erosion previously occurred or where studies indicated that future erosion was likely, due to the construction and operation of Warm Springs Dam. Maintenance responsibility for the channel stabilization project lies with SCWA, as established by an agreement between SCWA and USACE in June 1988. USACE provided to SCWA the *Warm Springs Dam and Lake Sonoma Project, Russian River Basin, Dry Creek Channel Improvements, Sonoma County, California Operation and Maintenance Manual* (Warm Springs Dam O&M Manual) (USACE 1991). This manual provides information, instruction, and guidance to the personnel responsible for proper operation, inspection, and maintenance of channel improvements and bank stabilization measures along Dry Creek downstream of Warm Springs Dam. Specific works are identified in the Warm Springs Dam O&M Manual.

Maintenance work associated with these sites can involve incidental sediment, vegetation, debris removal, and bank stabilization to ensure the structural integrity of the improvements. Outside of the work done on the 15 channel improvement sites in Dry Creek, additional vegetation removal for flood control or bank erosion is not performed in Dry Creek by SCWA or USACE.

Inspections are performed on the one non-federal levee (Public Law 84-99) on Dry Creek, and the property owner is informed of the needed repairs.

3.6.3.3 Bank Stabilization on the Russian River and Dry Creek

Bank stabilization activities by SCWA and the MCRRFCD on the Russian River and its tributaries are limited to maintenance of past channel improvement projects, several of which were implemented by USACE on the Russian River, and for which SCWA and the MCRRFCD are the local sponsoring agencies responsible for maintenance.

Examples of bank stabilization structures previously installed and now maintained, as necessary, include anchored steel jacks in single and multiple rows, flexible fence training structures, wire mesh and gravel revetments (i.e., retaining wall), and pervious erosion check dams. Anchored steel jacks, used in bank protection, are utilized to prevent streambanks from undercutting. The jacks are ¼-inch angle iron with 16-foot legs, cabled together and anchored to the streambank on the ends. Previous erosion check dams consist of gravel and wire mesh, and are used to control sheet erosion on streambanks. Many of the channel improvements described above were implemented to prevent erosion and provide bank stabilization. Many have been covered with soil, brush, and trees, and continue to provide the protection they were designed for with little or no maintenance needed.

The channel improvement areas and levees are inspected periodically by SCWA, MCRRFCD, and USACE. USACE then recommends maintenance work that may be needed. If a need for repairs is identified, those repairs are implemented and described in the annual reports to USACE.

In the Russian River, SCWA and MCRRFCD generally keep the project levees free from vegetation, remove instream gravel bars that may be impeding or diverting flow, and inspect and maintain the channel improvement sites. Typical maintenance recommendations for the channel improvement sites have included removing loose anchor jacks from the river, adding bank erosion protection, managing vegetation to reduce blockage of the river channel and increase access for maintenance and inspection of the banks, repairing or replacing loose grout or riprap, and removing driftwood.

SCWA and MCRRFCD are also responsible for inspecting certain levees along the upper Russian River under a program administered by USACE (PL 84-99). Inspections and small repairs to these non-project levees (non-federal sites) have typically been performed by SCWA. If major repairs are needed, the property owner and USACE are notified.

Streambank maintenance performed by MCRRFCD in the Russian River in Mendocino County consists of obstacle removal, streambank repair, and preventive maintenance. Because most bank erosion is caused by the river being directed into the riverbank by obstacles within the banks, most of the maintenance work is directed toward the removal of these in-channel obstacles. MCRRFCD assesses approximately 1/3 of the length of the river channel in Mendocino County each year, and works on sites identified within that area.

In Mendocino County, the summer flow, or low-water, channel is approximately 25 percent of the width of the winter flow, or high-water channel. The summer flow channel typically meanders from one side of the high-water channel to the other. In this configuration, willows have a tendency to take root on the inside bend of the low-flow channel during the summer and collect gravel during the ensuing winter. Bars tend to form as vegetation develops, creating low-velocity zones that encourage sediments to deposit. If left unchecked, this process continues until a willow-reinforced bar has developed to a size that is sufficient to divert the river into the high-water streambank, causing extensive bank erosion and river siltation. MCRRFCD has stated that, if left unchecked, the bars can, and have, developed into 10-foot high, 1,000-foot long, willow-covered deposits that obstruct and divert winter high-flows and increase the risk of bank erosion. This same condition exists in the Alexander Valley of Sonoma County.

MCRRFCD has maintained the river channel by removing willows from bars that develop as obstacles to high-water flows. Willow growth is controlled before a substantial bar can develop within the low-velocity waters created by the willows. If a riverbank failure occurs, the eroded bank material is often used to reestablish the high-water riverbank. Willows removed from bars are pushed against the bank where they take root and provide erosion control as well as riparian enhancement. This maintenance work is normally done at the end of the summer during low-flow conditions. This work has been performed with as little invasion into the stream channel as possible.

Major channel work has been performed by MCRRFCD in the past. Thousands of yards of gravel have been pushed up against the banks in an effort to provide bank stabilization and eliminate channel braiding. Currently, CDFG recommends actual removal of the gravel; however, MCRRFCD has not found removal of the gravel to be feasible.

Historically, extensive vegetation and sediment maintenance activities were conducted in the Russian River. Since coho salmon were listed under the ESA, these activities have been much more limited. Due to ESA considerations, USACE permits have not been issued for some activities. However, the activities described above represent baseline conditions.

3.6.4 GRAVEL BAR GRADING IN THE WOHLER AND MIRABEL AREA

Infiltration capacity at the Wohler and Mirabel diversion facilities is augmented by periodically recontouring gravel bars in the Russian River upstream and downstream of the inflatable dam. Protocols for this activity may differ from those conducted for channel maintenance, so these activities are discussed separately.

SCWA currently conducts grading at four bars in the Mirabel and Wohler areas. Three of the bars, the Bridge Bar, Wohler Bar, and McMurray Bar, are upstream of the inflatable dam. The bar at Mirabel is the Mirabel Bar. The McMurray and Mirabel bars are approximately 1,000 feet long and 200 feet wide. The other two gravel bars are approximately 500 feet long and 100 feet wide.

Gravel bar skimming operations may be performed in the spring of every year on the Wohler, McMurray, and Bridge gravel bars when streamflows drop below approximately 800 cfs, and before the dam is inflated. This work is performed at various times, depending on the flow in the river and demands on the water system, but the work is generally performed between March and July. The Mirabel gravel bar is skimmed between July and October, depending on flow conditions. Gravel at these locations is generally pushed up on the bank using bulldozers and scrapers, and is sometimes removed and stockpiled outside the channel.

3.6.5 FACTORS AFFECTING SPECIES ENVIRONMENT

Channel maintenance activities in the Russian River watershed are conducted to reduce the risk of flooding of local property and bank erosion. Effects of these activities under baseline practices were evaluated in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b).

The most urbanized portions of the watershed are in Santa Rosa and in the Cotati-Rohnert Park areas. These areas contain most of the constructed flood control channels. Conventional sediment maintenance activities in constructed flood control channels reduce fish passage to spawning and rearing habitat and restrict downstream migration. However, natural waterways and constructed channels in the Rohnert Park area are generally low-gradient and run through a valley plain to the Laguna de Santa Rosa. Poor summer water quality from urbanized areas and low summer flows limit rearing habitat in these channels. Since rearing habitat is limited, there is a moderate effect from sediment maintenance activities on salmonid populations.

Santa Rosa Creek drains to the Laguna de Santa Rosa, which in turn drains to Mark West Creek. Channel maintenance activities on constructed flood control channels and natural waterways in this part of the Mark West Creek watershed, including the Santa Rosa Creek watershed, have the potential to affect coho salmon and steelhead because this part of the watershed contains good rearing and spawning habitat for these species. Much attention has been given in recent years to restoration opportunities in this area. SCWA restoration actions within this watershed are outlined in Section 3.7.

SCWA channel maintenance activities under USACE obligations in Dry Creek are limited to maintenance of the 15 channel improvement sites. Potential spawning and rearing habitat for steelhead and Chinook salmon occurs in Dry Creek. Dry Creek does not currently contain much suitable coho salmon rearing habitat, but coho salmon may use Dry Creek for some or all of their life-history stages. Although removal of riparian vegetation at a few site-specific locales may reduce cover and shading, the effects to listed fish species are limited. Vegetative growth along riprap sites is retained as long as it does not threaten slope stability or encourage erosion.

Bank stabilization activities in the Russian River potentially may have affected populations of listed fish species, because large amounts of river and stream channel habitat have been altered. The most valuable spawning and rearing habitat occurs upstream of Asti in Mendocino County. Gravel bar grading and vegetation removal potentially affects listed fish species by reducing pool habitat formation, causing loss of high-flow refugia, and reducing shade canopy and cover. Loss of riparian vegetation associated with bank stabilization activities in the mainstem Russian River may have a moderate effect when shade canopy and cover are reduced.

Gravel bar grading occurs in the Mirabel and Wohler area to increase infiltration to the aquifer. The 2-mile reach above the inflatable dam at Mirabel has relatively few structural features that would create low areas outside the main channel. Given the characteristics of the river, gravel bar grading is not likely to significantly change the geomorphology of the channel. Effects from gravel bar grading operations are restricted to immediate, short-term effects, including a low risk of entrapment of migrating juveniles and short-term turbidity spikes as the Mirabel Bar is isolated or reconnected to the river. Therefore, the overall risk for injury and habitat degradation is low. The gravel bar grading activity in the upstream sites normally occurs after the coho salmon and Chinook salmon outmigration periods, although in some years it may occur during the later portion of the outmigration. There is a greater risk to steelhead juveniles, which are more likely to be present during gravel bar grading work. However, implementation of BMPs evaluated during the Mirabel Rubber Dam/Wohler Pool monitoring study (Chase et al. 2000) reduces the risk. Gravel bar grading at Mirabel normally occurs in late summer, and does not normally coincide with outmigration of salmonids. Fish rescues are conducted, and no salmonids were found in fish rescues in 1999.

3.7 RESTORATION AND CONSERVATION ACTIONS

SCWA has implemented many projects over the past several years that are designed to contribute to the conservation of natural resources in the Russian River watershed, particularly species listed under the ESA. This includes projects that SCWA has funded or implemented with staff time and materials, or with a combination of SCWA funding and other resources. These efforts include the general categories of watershed management, riparian and aquatic habitat protection, restoration, and enhancement. Actions that have been implemented before the MOU was signed (December 31, 1997) are part of the baseline.

3.7.1 Watershed Management

SCWA historically has been involved with watershed management activities in the Russian River watershed. Recently, SCWA has taken a more proactive role with regard to restoration and enhancement projects, and stewardship of the watershed. Several specific projects related to SCWA's contributions to watershed management in the Russian River basin are described below.

In March 1995 and October 1996, SCWA conducted two public workshops before its Board of Directors on watershed management activities and, specifically, SCWA's role in those activities. In August 1996, SCWA published the report, *The Russian River: An Assessment of Its Condition and Governmental Oversight*. In January 1997, SCWA began publishing the *Russian River Bulletin*, an interagency publication circulated among government agencies and other interested parties to describe new programs, legislation affecting or involving the Russian River, and the status of ongoing projects. In addition, SCWA has created a library, available to the public and other agencies, containing reports, documents, and other information pertinent to the Russian River watershed.

3.7.1.1 Russian River Basin Plan Review

SCWA is providing funding for the NCRWQCB to conduct a review of its Russian River Basin Plan (Basin Plan) to determine whether the requirements of the Basin Plan are sufficient to protect fish species in the Russian River. This information will assist ongoing efforts in the Russian River watershed for watershed management and protection of listed fish species. It will not only provide more information on the requirements of these species, but also an assessment of the adequacy of existing regulatory requirements in protecting these species. The review may lead to changes in regulatory standards.

3.7.2 Riparian and Aquatic Habitat Protection, Restoration, and Enhancement

3.7.2.1 Fisheries Enhancement Program Project Descriptions

SCWA began implementation of the FEP in 1996. SCWA's Board of Directors has directed SCWA to develop the FEP for the tributaries of the Russian River watershed. Since 1996, SCWA has issued an annual Request for Proposals (RFP) for fisheries enhancement work within the Russian River watershed. Projects funded to date have included both on-the-ground restoration and research efforts.

Since 1996, SCWA has granted funds to various entities each year to provide habitat restoration and research on listed fish species in the Russian River watershed. For example, SCWA has provided funding to nonprofit groups, private landowners, and public agencies through the FEP program. In addition, SCWA has contributed staff time and materials to many of these projects.

In addition to the FEP projects, SCWA provided staff and materials for a training session on instream habitat enhancement structure construction in 1996. The training was offered to individuals in the community interested in working on habitat improvement projects, creating a pool of trained individuals to work with SCWA and CDFG on future habitat improvement projects.

1. Stream Habitat Surveys

   Stream habitat surveys have been conducted in cooperation with CDFG each year of the FEP since 1996, and are intended to assess the habitat conditions of streams that are potentially viable for salmonid production. The surveys are used to identify streams that are in need of enhancement or restoration. Surveys are conducted according to the CDFG Habitat Restoration Manual. All data gathered are entered into CDFG's computer program to prioritize stream restoration projects. SCWA has allocated staff and materials for this project.

2. Temperature Data Collection

   Water temperature monitoring has been conducted each year of the FEP since 1996 in collaboration with CDFG and Mendocino County Water Agency. These data will be used to identify streams that provide suitable summer thermal conditions for salmonid juvenile rearing. Data loggers (i.e., equipment to monitor and record water quality measurements at specific intervals) are removed annually from each stream during the fall and deployed again the following spring. Temperature data have been collected in the following watersheds: Mark West, Maacama, Austin, East Austin, Santa Rosa, Dutch Bill, Hulbert, Dry, Brush, Matanzas, and Big Sulphur creeks, as well as in the mainstem. SCWA has allocated staff and equipment for this project. The Mendocino County Water Agency compiles all temperature data into a single database.

3. Water Quality Sampling

   This project includes collecting and identifying invertebrates from several streams in the Russian River watershed and analyzing the samples as indicators of water quality. Reference streams identified by CDFG have been sampled for a minimum of 2 years to establish a baseline reference condition. Other streams sampled are compared to those reference streams to determine relative water quality status. This project has been implemented each year since 1996. SCWA contributes staff and materials for the project. Additionally, SCWA provided funding for analysis of samples.

4. Instream Habitat Improvements

   SCWA has funded and/or implemented projects every year since 1996 to improve habitat in stream channels. Streams identified as candidates for instream habitat improvements include Green Valley, Freezeout, Dutch Bill, and Austin creeks. Instream habitat structures placed in these streams consist of large woody debris, such as rootwads, that provide salmonids protective cover from predators and that promote development of pools. Fencing has also been installed. SCWA provided matching funds and staff support for these projects.

5. Riparian Restoration

   SCWA has funded and/or implemented projects on Little Briggs, Green Valley, Austin, Copeland, and Freezeout creeks to exclude livestock from the riparian zone adjacent to the stream, and to replant degraded areas with native vegetation. These projects were intended to allow riparian vegetation to re-establish, stabilize streambanks, and decrease animal waste entering the stream. On Green Valley Creek, SCWA has also worked with Trout Unlimited and the landowners to provide temporary water supplies to restored riparian areas to increase the survival of newly planted trees. On Porter and Matanzas creeks, SCWA has implemented projects to enhance riparian habitat and stabilize streambanks. These projects consisted of placing bioengineered erosion structures such as willow mattresses and baffles, planting native riparian trees in upslope areas, and educating landowners on ways to prevent erosion and the value of riparian vegetation along streambanks on their property. SCWA has provided funding, staff, and materials for these projects.

6. Green Valley Creek Restoration

   Two restoration projects were implemented to improve habitat conditions for coho salmon and steelhead in Green Valley Creek, both designed to reduce streambank erosion. Green Valley Creek is one of the few tributaries in the Russian River watershed that still supports a self-sustaining, although diminished, population of threatened coho salmon. The Green Valley Creek watershed is held entirely in private ownership, and efforts aimed at improving habitat conditions for species recovery require the voluntary participation of landowners. Trout Unlimited and CDFG constructed two streambank stabilization projects in 1996 that did not perform as intended. One failed in 1998 and the other was in danger of failing. The sites delivered substantial amounts of fine sediment to the stream. Dragonfly Stream Enhancement, in conjunction with two private landowners, repaired both projects and arrested accelerated erosion at both sites. The site improvements include sloping and armoring of an eroding bank, planting of native vegetation to stabilize the sites, and removal of non-native vegetation. SCWA provided funding for the project.

Table 3-15 summarizes actions that are part of the baseline, and indicates the listed fish species the action is likely to affect, where known. Steelhead are the most abundant species in many of these areas, but as coho salmon or Chinook salmon populations are recovered, utilization of these streams by these species is likely to increase. All projects listed are likely to improve habitat for spawning, rearing, and migration of listed salmonids.

Table 3-15 Summary of Restoration and Conservation Actions

Creek	Type of Project	Size of Project	Species Affected[1]
Baseline Projects[2]			
Instream Habitat Improvements			
Green Valley	Contiguous structures and fencing	~ 1 mile	Co, St
Freezeout	3 non-contiguous structures		Co, St
Riparian Restoration			
Green Valley (streambank stabilization)	Erosion control	2 small projects	Co, St
Green Valley (livestock exclusion)	Fencing	> 1 mile	Co, St
Freezeout	Fencing	3,000 feet	St
Little Briggs	Fencing	> 1 mile	St
Porter	Willow walls & mattresses	~300 feet	St

[1] Co = Coho salmon, St = Steelhead, Ch = Chinook salmon
[2] Actions completed prior to December 31, 1997.
The size of the project is the actual length of stream affected.

3.8 FISH PRODUCTION FACILITIES AND OPERATIONS

The DCFH and CVFF are fish production facilities located in the Russian River basin. The DCFH (also referred to as the Warm Springs Fish Hatchery) is located on Dry Creek at the base of Warm Springs Dam. The CVFF is a satellite facility for the steelhead program at DCFH and is located on the East Fork Russian River at the base of Coyote Valley Dam. Both fish production facilities are owned by USACE and operated by CDFG under a cooperative agreement with USACE. Like all anadromous fish hatcheries in California, the Russian River facilities were developed to mitigate for the loss of spawning and rearing habitat for anadromous salmonids resulting from the construction of dams (CDFG and NMFS 2001).

Fish production goals for the DCFH were established in 1974 to compensate for the estimated loss of coho salmon and steelhead production in Dry Creek upstream of Warm Springs Dam. Additional fish production was included in the hatchery program goals to enhance harvest opportunities for coho and Chinook salmon in the Russian River (USFWS 1978). Fish production goals for CVFF were established in 1984 to compensate for the estimated loss of steelhead production in the East Fork Russian River upstream of Coyote Valley Dam (USACE 1986a). The DCFH and CVFF facilities went into service in 1980 and 1992, respectively.

This section outlines the fish production facilities and their operations as mitigation and enhancement hatcheries under the baseline condition. A detailed description of the baseline program is presented in *Interim Report 2: Fish Operations Facility* (FishPro and ENTRIX, Inc. 2000). Changes in fish facility operations that have occurred since

December 31, 1997 (the defined end of the environmental baseline period) are described as part of the proposed project in Section 4.

3.8.1 Background of Fish Facility Development

To compensate for loss of spawning and rearing habitat upstream of Warm Springs Dam and Coyote Valley Dam, various laws were enacted that ultimately led to the development of DCFH and CVFF. Construction of DCFH was authorized by the Flood Control Act of 1962. DCFH went into service on October 1, 1980.

Section 203 of the Flood Control Act of 1962, later modified by Section 95 of Public Law 93-251, the Water Resources Development Act of 1974, requires a program to compensate for fish losses on the Russian River attributed to the operation of Coyote Valley Dam. In January 1983, the South Pacific Division USACE directed the Sacramento District USACE to assume responsibility for the Coyote Valley Dam Fish Mitigation Project, and to determine what work would be required to comply with Public Law 93-251. The determination resulted in the development of CVFF, along with an expansion of DCFH. Both CVFF and the DCFH expansion became operational in 1992. In October 1996, the South Pacific Division USACE transferred control of Lake Sonoma and Lake Mendocino, including both fish facilities, to the San Francisco District USACE.

Before the fish facilities became operational, no quantitative estimates were conducted to determine the actual carrying-capacity of affected areas. Instead, mitigation goals were developed from run-size estimates within the sub-basins, with additional estimates based on the proportions of coho salmon and steelhead spawning habitat upstream of the dam locations. However, insufficient data existed to support these estimates. For coho salmon and steelhead, population estimates vary widely among studies because they are based on anecdotal information or on assumptions of habitat quality.

CDFG estimated that, before the construction of Warm Springs Dam, the Dry Creek sub-basin supported a run of approximately 8,000 steelhead and 300 coho salmon (CDFG 1970). Approximately 75 percent of the steelhead (6,000) and 33 percent of the coho salmon (100) were believed by CDFG to spawn in sections of Dry Creek and its tributaries that are now upstream of the dam (CDFG 1970). Salmon and steelhead continue to use Dry Creek downstream of the dam for spawning and rearing.

Various estimates of the annual adult steelhead run size in the East Fork Russian River before construction of Coyote Valley Dam ranged from 36 to 7,684 fish (Prolysts, Inc. and Beak Consultants, Inc. 1984). USACE concluded that it would be necessary to produce 4,000 adult steelhead each year to provide adequate mitigation for losses resulting from construction and operation of Coyote Valley Dam (USACE 1986b).

3.8.2 Fish Facility Program Goals

DCFH and CVFF program goals were established to develop and maintain an escapement of 1,100 adult coho salmon, 6,000 adult steelhead, and 1,750 adult Chinook salmon in the Dry Creek drainage, and 4,000 adult steelhead in the upper Russian River drainage. To achieve these escapement goals, production goals were also established for egg harvest and fish-release numbers at DCFH. Similarly, goals for egg-harvest numbers and pounds of yearling releases were established for CVFF. Based on a desired CVFF release size of five fish per pound, the 40,000 pounds of steelhead can be equated to 200,000 steelhead individuals. Production and adult escapement goals for DCFH and CVFF as they existed during the environmental baseline period are summarized in Table 3-16.

Table 3-16 Baseline Hatchery Program Goals for DCFH and CVFF

Location/Species	Mitigation/ Enhancement	Egg Harvest	Juvenile Releases	Adult Escapement
Don Clausen Fish Hatchery				
Steelhead	Mitigation	600,000	300,000 yearling	6,000
Coho Salmon	Mitigation	20,000	10,000 yearling	100
Coho Salmon	Enhancement	200,000	100,000 yearling	1,000
Chinook Salmon	Enhancement	1,400,000	1,000,000 smolts	1,750
Coyote Valley Fish Facility				
Steelhead	Mitigation	320,000	200,000 yearling	4,000

When the baseline hatchery program goals were developed, CDFG established the following definitions and management guidelines:

Coho Salmon:

Yearling release size: 10 fish per pound or larger

Fecundity: 2,000 eggs per female

Survival from unfertilized egg to stocked yearling: 50 percent

Survival from stocked yearling to adult return at hatchery: 1 percent

Steelhead:

Yearling release size: 4 to 5 fish per pound or larger

Fecundity: 5,000 eggs per female

Survival from unfertilized egg to stocked yearling: 50 percent

Survival from stocked yearling to adult return at hatchery: 2 percent

Chinook Salmon:

Smolt: 50 fish per pound or larger (typical for April-May releases)

Yearling release size: 10 fish per pound or larger (typical for November releases)

Fecundity: 4,000 eggs per female

Survival from unfertilized egg to stocked smolt: 75 percent

Survival from stocked smolt to adult return at hatchery: 0.175 percent

The baseline program goals for DCFH and CVFF include an assumed survival rate from release to adult return at the hatchery. Actual survival following release is affected by many factors beyond the control of hatchery operations. While hatchery practices may influence marine survival of salmon, marine survival is also related to ocean-wide factors in the marine environment in the North Pacific, such as climate changes (Beamish and Bouillon 1992). In addition, commercial and sport harvest can have a significant effect on hatchery returns. The stated management goals for survival from yearling release to hatchery return are 2 percent for steelhead and 1 percent for coho salmon. CDFG has noted that these values are higher than the current survival rates for some west coast hatchery stocks of steelhead and coho salmon (B. Coey, CDFG, pers. comm. March 29, 2000a). For example, the 10-year average survival of hatchery winter steelhead released in the East Fork Hood River in Oregon is 0.26 percent, based on the results of the Oregon Department of Fish and Wildlife (ODFW) coded wire tag program (Lewis et al. 2002). If actual conditions experienced by the Russian River stocks are not able to support the assumed survival rate, it is unlikely that the desired adult escapement will ever be achieved if release goals are followed.

No estimates of post-dam carrying-capacity have ever been developed to confirm that the remaining spawning and rearing habitat is capable of supporting the mitigation and enhancement production goals. Also, there are no programs specified in the goals to assess the potential for competition among naturally-spawned and hatchery-spawned components of the same species, or between any of the three salmonid species or other fauna present in the Russian River during the same time periods.

3.8.3 Fish Facility Operations

The following three subsections summarize fish facility operations in the Russian River basin for coho salmon, steelhead, and Chinook salmon. These summaries focus on activities conducted under the DCFH and CVFF mitigation and enhancement programs, but also provide an overview of fish stocking activities conducted prior to implementation of these hatchery programs.

3.8.3.1 Coho Salmon

Historical Stocking Activities

Between 1937 and 1998, approximately 2.3 million hatchery coho were planted in the Russian River basin (Table 3-17). Most of these outplants (approximately 70 percent) occurred between 1981 and 1998 with implementation of the DCFH coho mitigation and enhancement program. This program was discontinued in 1999 due to the lack of sufficient numbers of Russian River coho broodstock.

Steiner Environmental Consulting's review of hatchery records (1996) revealed that at least five out-of-basin coho stocks were introduced to the Russian River as a result of outplanting, most of them from North Coast region hatcheries. These out-of-basin broodstock sources (with the last known year of planting noted in parentheses) included the Alsea River, Oregon (1972), Eel River (1990), Klamath River (1988), Noyo River (1998), and Soos Creek, Washington (1978). The management plan developed for implementation of the DCFH and CVFF programs stated that coho eggs from the Noyo and Eel rivers were acceptable for use in meeting the mitigation and enhancement goals for the DCFH coho program. Russian River coho served as the broodstock for 32 percent of all outplants between 1937 and 1998 (Table 3-17).

Table 3-17 Broodstock Source, Stocking Year, and Number of Coho Salmon Outplanted in the Russian River, 1937 to 1998

Broodstock Source	Years Outplanted	Total Outplants[1]
Russian River	1983, 85-98	752,372
Alsea River, Oregon	1972	58,794
Eel River	1987, 90	25,112
Klamath River	1975, 81-83, 86-88	451,370
Noyo River	1970, 72-74, 82-84, 86-91, 93, 97-98	687,820
Soos Creek, Washington	1978	8,420
Unknown		403,340
Total		**2,387,228**
% Russian River Origin[2]		**32%**

[1] Data compiled from Steiner Environmental Consulting (1982-2003) and DCFH (1996, 1997, and 1998). Some historical records are incomplete. This compilation is intended to convey general magnitude of hatchery planting rather than exact numbers.
[2] As planting records are incomplete, this is only an estimate based on numbers presented in this table. Out-of-basin sources were planted extensively in the past, but this practice was diminished and then discontinued in more recent years.

Distinct periods of coho stocking activities have been described by Steiner Environmental Consulting (1996). The first hatchery coho plant occurred in 1937 with the release of 171,500 fish. No more hatchery coho were planted until 1963. From 1940 to 1980, the Russian River received more than 1.8 million outplants of coho "rescued" from summer-intermittent streams, 44 percent of which came from basins outside the Russian River. (These outplants of rescued fish are not included in the data in Table 3-17.) A third period of activity occurred from 1963 to 1998, when approximately 2 million hatchery coho were planted. During this period, the DCFH program worked to develop a basin-adapted strain of coho to use as the program's broodstock. This is evidenced by the fact that, between 1963 and 1980, all of the outplants were from out-of-basin stocks; between 1980 and 1989, 15 percent of broodstock came from returning Russian River adults captured at the DCFH facility; and between 1990 and 1995, 85 percent of broodstock were returning Russian River adults (Steiner Environmental Consulting 1996).

There is no known information regarding the survival of fish from coho outplants prior to the DCFH program. Given the magnitude and duration of historical coho stock transfers, it is likely that naturally-spawning coho salmon within the Russian River represent a genetic conglomerate of many stocks. Similarly, coho broodstock for the DCFH program are likely to be descendants of many stocks. While the history of stock transfers in the Russian River suggests that genetic integrity has been compromised, the considerable efforts made after 1980 to collect broodstock from Russian River returns should allow selection and genetic drift to give rise to Russian River-specific stocks.

Broodstock Selection and Mating

Russian River coho broodstock for the DCFH program were collected from fish entering the DCFH ladder and trap. Adult collection and spawning protocols at DCFH require systematic collection across the entire adult return period. Coho program guidelines were aimed to collect and spawn a minimum of 110 females, and generally 1.5 to 2 times those numbers for males. In practice, it is common that more individuals are spawned than are necessary to achieve egg-take goals, both to increase genetic diversity and to protect against catastrophic loss during incubation and early rearing. If there were insufficient Russian River coho salmon to achieve the program egg-take goals, it was acceptable to transfer coho eggs from the Noyo River and/or Eel River to meet the goals.

Between 1993 and 1998, the number of female Russian River coho used as broodstock varied (Table 3-18). The number of males and jacks used as broodstock during this period was not recorded in hatchery records, but has been estimated based on the general spawning protocols in effect at the time. During this period, any naturally-spawned coho that voluntarily entered the traps were retained as broodstock whenever possible. The specific number of naturally-spawned adults used as broodstock is not known, but it has been stated that returning hatchery-reared individuals were the primary source of broodstock (R. Gunter, CDFG, pers. comm. 1999). The DCFH mitigation and enhancement program was terminated in 1999.

Table 3-18 Coho Broodstock Spawning Levels at DCFH from 1993 to 2003

Year[1]	Females (actual)[2]	Males (approx.)[3]
1993-1994	57	114
1994-1995	349	698
1995-1996	32	64
1996-1997	147	294
1997-1998	0	0
1998-1999[4]	0	0
1999-2000[4, 5]	NA	NA
2000-2001[4, 5]	NA	NA
2001-2002[4, 5]	NA	NA
2002-2003[4, 5]	NA	NA

1 Operating year for CDFG extends from July 1 of first year to July 30 of second year.
2 Data regarding females spawned compiled from DCFH annual reports.
3 Total number of males estimated by assuming spawning ratio of 2 males:1 female (CDFG 2002).
4 Activities after 1997 to 1998 are not part of the baseline.
5 The coho mitigation and enhancement program was terminated in 1999.

Rearing and Release

Incubation and fry-rearing functions for the DCFH coho program were conducted inside the DCFH hatchery building. Approximately 6 weeks after hatching, it was typical to transfer the fry into outdoor concrete raceways. Annually, beginning in November, grading was conducted on all coho; those larger than 10 per pound were released to Dry Creek. The DCFH/CVFF management plan stipulated that, in April, any remaining fish that had not yet reached target size were to be released to Dry Creek as well.

Annual release data for the DCFH coho program is presented in Table 3-19, noting the total release number, pounds, and average size at release. The data reflect all releases that occurred between facility start-up through June 2003, even though the environmental baseline ends with the 1997 to 1998 year. Coho salmon releases surpassed the production goal of 110,000 from 1987 to 1992, but poor returns in recent years did not allow adequate egg harvest to meet production goals. Comparison of relevant data on adult returns and egg harvest indicates that coho salmon release numbers are directly related to availability of broodstock, and low release numbers should not be construed as a reflection of hatchery operations. Survival from unfertilized egg to stocked yearling routinely surpassed the management goal of 50 percent.

Release protocols for the coho salmon program called for the fish to be sorted by size; larger individuals were released, while smaller individuals were retained until reaching a larger size. Larger individuals are assumed to emigrate more quickly than smaller individuals, thereby decreasing the risk of freshwater predation and competition. Furthermore, releases were not made in the smaller tributaries where primary spawning and rearing occurs, with the exception of Dry Creek. DCFH releases use a transport truck to haul the fish from the hatchery to their final release location in Dry Creek.

Due to release locations, all coho salmon were acclimated to the Russian River system, suggesting that straying to out-of-basin rivers was unlikely to be a great concern. The DCFH coho rearing program is accomplished using Lake Sonoma water, and releases occur approximately 3 miles downstream from the hatchery in Dry Creek, which emanates from Lake Sonoma. Coho salmon would be expected to return to capture facilities in Dry Creek, rather than to non-natal tributaries.

Table 3-19 Don Clausen Fish Hatchery Coho Salmon Release History

Year[1]	Fingerling			Yearling		
	Number	Pounds	Avg FPP[2]	Number	Pounds	Avg FPP[2]
1981-1982	66,400	1,050	63	30,820	4,600	7
1982-1983	82,987	1,190	70	32,305	3,310	10
1983-1984	3,800	126	30	30,310	4,330	7
1984-1985	67,750	1,010	67	0	0	0
1985-1986	42,525	525	81	86,425	7,325	12
1986-1987	40,809	704	58	123,570	16,250	8
1987-1988	82,211	1,350	61	104,324	17,875	6
1988-1989	0	0	0	100,680	13,083	8

Table 3-19 Don Clausen Fish Hatchery Coho Salmon Release History (Continued)

Year[1]	Fingerling			Yearling		
	Number	Pounds	Avg FPP[2]	Number	Pounds	Avg FPP[2]
1989-1990	0	0	0	128,755	14,200	9
1990-1991	0	0	0	110,690	12,625	9
1991-1992	0	0	0	137,400	15,075	9
1992-1993	0	0	0	85,859	10,605	8
1993-1994	0	0	0	55,528	9,700	6
1994-1995	0	0	0	27,186	2,699	10
1995-1996	0	0	0	96,180	27,570	3
1996-1997	0	0	0	23,380	8,500	3
1997-1998	0	0	0	49,245	8,045	6
1998-1999[3]	0	0	0	0	0	0
1999-2000[3, 4]	0	0	0	0	0	0
2000-2001[3, 4]	0	0	0	0	0	0
2001-2002[3, 4]	0	0	0	0	0	0
2002-2003[3, 4]	0	0	0	0	0	0
Avg - all years	17,567	271	20	55,621	8,048	6
Avg - releases	55,212	851	61	76,479	11,066	8

1 The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
2 Avg FPP = average size (fish per pound) at release.
3 Releases made after the 1997 to 1998 year are not part of the baseline.
4 The coho mitigation and enhancement program was terminated in 1999.

Adult Returns

Adult returns to DCFH are presented in Table 3-20. The coho salmon mitigation goal of 100 adult fish has been met 11 out of 19 years, but the enhancement goal calling for an additional 1,000 adult returns has never been achieved. It is suggested that the survival estimate of 1 percent stated in the DCFH and CVFF management plan established optimistic and unrealistic expectations for adult escapement goals.

Table 3-20 History of Coho Salmon Trapped at Don Clausen Fish Hatchery

Year[1]	Male	Female	Grilse	Total
1980-1981	0	0	0	0
1981-1982	2	2	0	4
1982-1983	515	277	194	986
1983-1984	0	1	8	9
1984-1985	32	44	0	76
1985-1986	0	0	0	0
1986-1987	139	5	328	472
1987-1988	164	155	257	576
1988-1989	219	139	176	534
1989-1990	35	35	70	140
1990-1991	100	87	90	277
1991-1992	53	20	89	162
1992-1993	250	113	215	578

Table 3-20 History of Coho Salmon Trapped at Don Clausen Fish Hatchery (Continued)

Year[1]	Male	Female	Grilse	Total
1993-1994	110	62	277	449
1994-1995	310	392	63	765
1995-1996	13	13	36	62
1996-1997	68	68	12	148
1997-1998	1	3	0	4
1998-1999[2]	2	1	5	8
1999-2000[2, 3]	1	0	0	1
2000-2001[2, 3]	0	0	0	0
2001-2002[2, 3]	0	0	0	0
2002-2003[2, 3]	0	0	0	0
Average	88	62	79	228

1 The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
2 Activities after 1997-1998 are not part of the baseline.
3 The coho mitigation and enhancement program was terminated in 1999.

Harvest Management

Harvest of coho salmon is prohibited within the Russian River basin. However, there is a fishery within the basin for hatchery-reared steelhead. While this strategy minimizes direct fishing mortality of coho salmon, indirect effects such as hooking mortality and harassment may still occur. There are no current estimates for incidental harvest levels of coho salmon within the Russian River.

Rearing for Out-of-Basin Programs

Until 1999, DCFH received eggs from a coho salmon stock in the Noyo River. Adult fish used as the source of these eggs were tested for viral pathogens (W. Cox, pers. comm., 1999). Upon arrival at the DCFH, the Noyo River eggs were disinfected with iodophore solution to remove surface pathogens that may have been present. Egg lots were incubated separately until completion of viral certification, after which time the egg lots could be combined. After reaching the eyed-egg lifestage, the eggs were transferred to the Mad River Hatchery for hatching, rearing, and release (R. Gunter, pers. comm., 1999). Occasionally, some of the eggs from this source were kept at DCFH and reared for planting into the Russian River for enhancement purposes; however, both this practice and the entire Noyo River incubation program were discontinued in 1999 (R. Gunter, pers. comm., 2000a, 2000b).

3.8.3.2 Steelhead

Historical Stocking Activities

Between 1870 and 1998, more than 33 million hatchery steelhead were planted in the Russian River basin. Before the 1980s, when the ecological distinctness of local stocks gained acceptance, it was common to stock rivers with the progeny of adult fish captured from basins where hatcheries were located. A detailed review of hatchery records conducted by Steiner Environmental Consulting (1996) revealed that, before 1980, at least seven out-of-basin steelhead stocks were introduced to the Russian River, most of them from hatcheries in the North Coast region. These out-of-basin broodstock sources (with the last known year of planting noted in parentheses) included the Eel River (1972), Prairie Creek (1927), Mad River (1981), San Lorenzo Creek (1973), Scott Creek (1911), and Washougal River (Washington) (1981). Russian River steelhead served as the broodstock for 54 percent of all outplants between 1870 and 1998 (Table 3-21).

Table 3-21 Broodstock Source, Stocking Year, and Number of Hatchery Steelhead Outplanted in the Russian River, 1870 to 1998

Broodstock Source	Years Outplanted	Total Outplants[1]
Russian River	1959, 81-98	18,167,885
Eel River	1914-19, 21-23, 58-59, 72	4,900,843
Mad River	1975-76, 78-79, 81	324,101
Prairie Creek	1927	249,000
San Lorenzo Creek	1973	83,350
Scott Creek	1911	433,458
Washougal	1980-81	270,360
Unknown		8,934,122
Total Outplants		**33,363,119**
% Russian River Origin[2]		**54%**

1 Data compiled from Steiner Environmental Consulting (1996) and DCFH (1996, 1997, and 1998). Some historical records are incomplete. This compilation is intended to convey general magnitude of hatchery planting rather than exact numbers.

2 As planting records are incomplete, this is only an estimate based on numbers presented in this table, using the conservative assumption that all unknown broodstock sources come from outside the Russian River basin. It was common in the past for hatcheries to plant fish in many basins. This practice has diminished since the 1980s and was discontinued in the Russian River in 1999.

Three distinct periods of steelhead stocking have occurred since 1870 (Steiner Environmental Consulting 1996). The first period, lasting until 1939, peaked between 1920 and 1929, when more than 5.6 million steelhead were planted. It is probable that most of these early planting efforts were comprised of fry and fingerling, which generally have a much lower survival rate than the yearling steelhead commonly planted today. The second period spans from 1939 to 1971 when very few hatchery steelhead were planted. During this period, however, the Russian River received more than 1.8 million outplants of fingerling steelhead "rescued" from summer-intermittent streams, 29 percent of which came from basins outside the Russian River. (These outplants are not included in the data in Table 3-21). The third distinct period is characterized by the outplanting activities of the DCFH and CVFF programs. More than 15 million steelhead were released from DCFH and CVFF between 1981 and 1998, representing 46 percent of all outplants listed in Table 3-18. During the start-up of DCFH in 1980 and 1981, eggs were obtained from Russian River adults captured within the basin, as well as from Mad River and Washougal River, Washington source stocks (R. Gunter, CDFG, pers. comm. 1999). All DCFH/CVFF steelhead broodstock since 1982 come from the Russian River basin. It is estimated that less than 1 percent of the 1981 to 1998 steelhead outplants came from out-of-basin broodstock sources.

There is no known information regarding the survival of fish from outplants prior to the DCFH/CVFF program. Even so, given the magnitude and duration of historical stocking, naturally-spawning steelhead within the Russian River probably represent a genetic conglomerate of many steelhead stocks. Similarly, steelhead broodstock used for the DCFH and CVFF programs are probably descendants of many stocks. Data are unavailable to quantify the degree of introgression that may have occurred due to historical stocking using out-of-basin broodstock. While the history of stock transfers in the Russian River suggests that genetic integrity has been compromised, the current policy of collecting broodstock exclusively from returns to the Russian River should allow selection and genetic drift to give rise to Russian River-specific stocks.

Broodstock Selection and Mating

Since 1982, the source of broodstock for Russian River steelhead outplants has been limited to adult fish trapped at DCFH and CVFF facilities (R. Gunter, CDFG, pers. comm. 1999). Broodstock for the DCFH program are collected from fish entering the DCFH ladder and trap, while those for the CVFF program are collected from fish entering the CVFF ladder and trap.

Adult collection and spawning protocols at DCFH and CVFF require systematic collection across the entire adult return period. Weekly capture goals are formulated using a distribution curve of adult returns, based on a running mean of adult returns during that week over the past several years. (A 9- to 11-year mean has been used in recent years, routinely showing that a vast majority of the adult return occurs within a 16-week period.) Steelhead program guidelines routinely aim to collect and spawn a minimum of 180 females at DCFH and a minimum of 120 females at CVFF, and generally 2.5 to 3 times those numbers for males. In practice, it is common that more individuals are spawned than are necessary to achieve egg-take goals, both in an attempt to increase genetic diversity and as a means to protect against catastrophic loss during incubation and early rearing.

Between 1991 and 1998, the number of female steelhead used as broodstock varied (Table 3-22). The number of males and jacks used as broodstock during this period was not recorded in hatchery records, but has been estimated based on the general spawning protocols in effect at the time. During this period, any naturally-spawned adults that voluntarily entered the traps were retained as broodstock whenever possible. The specific number of naturally-spawned adults used as broodstock is not known, but it has been stated that returning hatchery-reared individuals were the primary source of broodstock (R. Gunter, CDFG, pers. comm. 1999). The use of naturally-spawned steelhead as broodstock has not occurred since 1999.

Table 3-22 Steelhead Broodstock Spawning Levels at DCFH and CVFF from 1991 to 2003

Year[1]	DCFH Adults			CVFF Adults		
	Females (actual)[2]	Males (approx.)[3]	Jacks (approx.)[4]	Females (actual)[2]	Males (approx.)[3]	Jacks (approx.)[4]
1990-1991	159	395	2	NA	NA	NA
1991-1992	342	850	5	NA	NA	NA
1992-1993	365	907	5	106	263	2
1993-1994	342	850	5	123	306	2
1994-1995	292	726	4	92	229	1
1995-1996	250	621	4	118	293	2
1996-1997	241	599	4	117	291	2
1997-1998	157	390	2	107	266	2
1998-1999[5]	184	457	3	107	266	2
1999-2000[5]	184	457	3	128	318	2
2000-2001[5]	146	363	2	148	368	2
2001-2002[5]	179	445	3	169	420	3
2002-2003[5]	192	477	3	146	363	2

[1] CDFG operating year extends from July 1 of first year to July 30 of second year.
[2] Data regarding females spawned compiled from DCFH and CVFF annual reports.
[3] Total number of males (including jacks) estimated by assuming spawning ratio of 2.5 males:1 female (CDFG 2002).
[4] Number of jacks estimated assuming a 0.6 percent presence in the male population.
[5] Activities after 1997 to 1998 are not part of the baseline.

Rearing and Release

Incubation and fry rearing for the DCFH and CVFF steelhead programs is conducted inside the DCFH hatchery building. In early spring, the fish are transferred to outdoor raceways. In December, the first of three groups of CVFF steelhead is transferred from DCFH to the CVFF facility, where the fish undergo a 4- to 6-week acclimation period before being released to the East Fork Russian River. The second and third groups of CVFF steelhead are transferred in late January/early February and March, respectively. During this same period, DCFH steelhead remain at DCFH. As they reach their target release size (typically between mid-December and April), they are hauled via a transport truck and released into Dry Creek at Yoakim Bridge, approximately 3 miles downstream from DCFH.

Annual release data for the DCFH and CVFF steelhead programs are presented in Table 3-23, noting the total release number, pounds, and average size at release. The data reflect all releases that occurred between facility start-up through June 2003, even though the environmental baseline ends with the 1997 to 1998 year. Fingerling releases noted prior to the 1998 to 1999 year reflect the previous practice of releasing surplus eggs, fry, and fingerling into the drainage; this practice was terminated in July 1999. Similarly, some of the yearling release numbers prior to July 1999 may reflect the previous practice of releasing excess undersized fish that remained at the end of the season.

Table 3-23 DCFH and CVFF Steelhead Release History

Year[1]	Fingerling Number	Fingerling Pounds	Fingerling Avg FPP[2]	Yearling Number	Yearling Pounds	Yearling Avg FPP[2]
Don Clausen Fish Hatchery						
1981-1982	253,436	682	372	53,380	10,975	5
1982-1983	226,710	762	372	102,662	18,225	5
1983-1984	459,970	2,119	298	124,146	22,730	6
1984-1985	608,680	647	217	155,305	42,360	5
1985-1986	539,157	4,108	941	212,365	27,500	4
1986-1987	1,316,469	4,842	131	237,753	68,405	8
1987-1988	720,579	930	272	224,963	60,560	3
1988-1989	578,780	712	775	233,979	58,950	4
1989-1990	347,347	551	813	212,769	56,175	4
1990-1991	121,326	1,893	630	243,881	64,320	4
1991-1992	1,188,663	3,406	64	335,181	86,775	4
1992-1993	1,249,521	3,571	349	321,890	75,975	4
1993-1994	627,730	1,532	350	355,164	86,809	4
1994-1995	397,455	2,676	410	309,458	78,524	4
1995-1996	134,000	67	149	316,758	88,700	4
1996-1997	279,088	381	2000	312,388	86,376	4
1997-1998	119,681	522	733	348,734	99,295	4
1998-1999[3]	46,062	1,153	229	341,339	88,425	4
1999-2000[3]	0	0	0	300,000	75,000	4
2000-2001[3]	0	0	0	336,320	80,139	4
2001-2002[3]	0	0	0	284,378	85,950	3
2002-2003[3]	0	0	0	317,636	77,095	4
Avg - all years	333,975	1,419	354	309,707	80,462	4
Avg - releases	467,564	1,987	495	309,707	80,462	4
Coyote Valley Fish Facility						
1992-1993	0	0	0	165,469	26,839	6
1993-1994	227,313	365	372	213,872	46,472	5
1994-1995	107,667	238	298	235,416	44,659	6
1995-1996	76,670	6,950	217	224,702	44,647	5
1996-1997	122,188	594	941	206,333	40,400	4
1997-1998	110,981	369	131	242,438	48,528	8
1998-1999[3]	164,770	1,086	152	231,320	45,448	5
1999-2000[3]	0	0	0	229,451	43,813	5
2000-2001[3]	0	0	0	211,801	45,852	5
2001-2002[3]	0	0	0	206,264	49,047	4
2002-2003[3]	0	0	0	212,513	43,239	5
Avg - all years	73,599	873	159	216,325	43,540	5
Avg - releases	134,932	1,600	291	216,325	43,540	5

1. The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
2. Avg FPP = average size (fish per pound) at release.
3. Releases made after the 1997-1998 year are not part of the baseline.

In general, the DCFH steelhead production goals of 300,000 fish have been routinely achieved since 1992, following improvements in rearing facilities and water supply that were completed that year. Similarly, the CVFF production goals of 200,000 fish have been met since the first year following startup. Survival from unfertilized egg to stocked yearling routinely surpasses the management goal of 50 percent.

Adult Returns

Adult returns to DCFH and CVFF are presented in Table 3-24. Since operations began, DCFH has achieved the steelhead mitigation goal of 6,000 adult escapement only one time. At CVFF, the mitigation goal of 4,000 returning fish has yet to be achieved. Peak returns occurred in 1997, when 3,727 adult steelhead were counted at CVFF. It is suggested that the survival estimate of 2 percent stated in the DCFH and CVFF management plan established optimistic and unrealistic expectations for adult escapement goals.

Table 3-24 History of Steelhead Trapped at DCFH and CVFF

Year[1]	DCFH				CVFF			
	Male	Female	1/2-Pound	Total	Male	Female	1/2-Pound	Total
1980-1981	148	185	0	333				
1981-1982	124	235	0	359				
1982-1983	322	242	0	564				
1983-1984	1,039	923	0	1,962				
1984-1985	369	468	0	837				
1985-1986	812	484	4	1,300				
1986-1987	519	696	36	1,251				
1987-1988	660	375	10	1,045				
1988-1989	453	421	17	891				
1989-1990	428	260	15	703				
1990-1991	239	181	3	423				
1991-1992	750	834	7	1,591				
1992-1993	1,378	1,289	2	2,669	182	120	8	310
1993-1994	856	895	9	1,760	229	198	13	440
1994-1995	3,561	4,525	14	8,100	1,147	1,054	9	2,210
1995-1996	2,135	1,958	12	4,105	1,129	980	6	2,115
1996-1997	1,729	1,910	9	3,648	1,793	1,934	8	3,735
1997-1998	656	687	1	1,344	619	932	8	1,559
1998-1999[2]	1,219	1,012	5	2,236	793	798	5	1,596
1999-2000[2]	1,509	1,794	11	3,314	976	1292	2	2,270
2000-2001[2]	1,941	1,537	2	3,480	929	995	4	2,270
2001-2002[2]	2,032	2,087	1	4,120	1,486	1,860	0	3,346
2002-2003[2]	1,488	1,854	0	3,342	959	1,087	1	2,047
Average	1,059	1,081	7	2,147	931	1,023	6	1,991

[1] The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
[2] Activities after the 1997-1998 year are not part of the baseline.

Harvest Management

Current fishing regulations allow the take of hatchery-reared steelhead. (Steelhead releases from DCFH and CVFF are marked with clipped adipose fins.) Harvest of naturally-spawned steelhead is prohibited. While this strategy minimizes direct fishing mortality, indirect effects such as hooking mortality and harassment may still affect naturally-spawned adults. There are no current estimates of harvest levels of steelhead within the Russian River.

3.8.3.3 Chinook Salmon

Historical Stocking Activities

Between 1881 and 1998, approximately 8.7 million hatchery Chinook salmon were planted in the Russian River basin (Table 3-25). A detailed review of hatchery records conducted by Steiner Environmental Consulting (1996) revealed that at least six out-of-basin Chinook salmon stocks were introduced to the Russian River as a result of outplanting, using broodstock sources tracing back to North Coast, Sacramento River, and Wisconsin hatcheries. These out-of-basin broodstock sources (with the last known year of planting noted in parentheses) included the Eel River (1998), Klamath River (1956), Mad River (1953), Sacramento River (1964), Silver King Creek (1983), and Wisconsin (1986). The management plan developed for implementation of the DCFH program stated that Chinook salmon eggs from the Eel River system were acceptable to use to meet the enhancement goals for the DCFH Chinook salmon program. Russian River Chinook salmon served as the broodstock for approximately 6 percent of all outplants between 1881 and 1998 (Table 3-25).

Table 3-25 Broodstock Source, Stocking Year, and Number of Chinook Salmon Outplanted in the Russian River, 1881 to 1998

Broodstock Source	Years Outplanted	Total Outplants[1]
Russian River	1985, 87-90, 92-98	542,478
Eel River	1982, 84, 86-89, 96-98	218,257
Klamath River	1955-56	1,000,000
Mad River	1953	9,250
Sacramento River	1956, 59-60, 62-64	3,283,295
Silver King Creek	1982-83	70,000
Unknown		2,265,292
Wisconsin[2]	1982-86	1,337,624
Total		**8,726,196**
% Russian River Origin[3]		**6%**

[1] Data compiled from Steiner Environmental Consulting (1996) and DCFH (1996, 1997, and 1998). Some historical records are incomplete. This compilation is intended to convey general magnitude of hatchery planting rather than exact numbers.

[2] West Coast hatchery strains of Wisconsin strain Chinook salmon originate from the Green River Hatchery in Washington.

[3] Because planting records are incomplete, this is only an estimate based on numbers presented in this table. Out-of-basin sources were planted extensively in the past, but this practice was diminished and then discontinued in more recent years.

Distinct periods of Chinook salmon stocking activities were described by Steiner Environmental Consulting (1996). The first hatchery Chinook salmon plant occurred in 1881 with the release of 15,000 fish, and subsequent hatchery plantings were sporadic until 1949. In 1949, a consistent program was begun in an effort to establish a viable population of Russian River Chinook salmon, using early-run stocks of fall Chinook salmon. In 1962, it was decided that the failure of these efforts was likely due to the adversely high water temperatures encountered by the returning adult fish. Efforts from 1963 to 1970 used a later-run stock of fall Chinook salmon, but still failed to establish a viable population. With the implementation of the DCFH program in 1982, a systematic effort was made to develop a basin-adapted strain for the program by planting progeny of adults returning to the hatchery. Between 1980 and 1989, only 15 percent of Chinook salmon plantings came from Russian River broodstock captured at the DCFH facility; between 1990 to 1995, 100 percent of plantings came from returning Russian River broodstock (Steiner Environmental Consulting 1996). There have been no outplants for the DCFH Chinook salmon enhancement program since 1998.

There is no known information regarding the survival of fish from Chinook salmon outplants prior to the DCFH program. Recent monitoring efforts suggest that a naturally-spawning Chinook salmon population currently exists within the Russian River basin (see Section 2.2.3.3). Given the magnitude and duration of historical Chinook salmon stock transfers, it is likely that naturally-spawning Chinook salmon within the Russian River represent a genetic conglomerate of many stocks. Similarly, Chinook salmon broodstock for the DCFH program were likely to have been descendants of many stocks. Data are unavailable to quantify the degree of introgression that may have occurred due to historical stocking using out-of-basin broodstock. While the history of stock transfers in the Russian River suggests that genetic integrity has been compromised, the considerable efforts made after 1982 to collect broodstock from returns to the Russian River contributed to allowing selection and genetic drift to give rise to Russian River-specific stocks. A recent study (Hedgecock et al. 2003) indicates that Chinook salmon in the Russian River are not closely related to Central Valley or Eel River populations, and concludes that they belong to a diverse set of coastal populations.

Broodstock Selection and Mating

Russian River Chinook salmon broodstock for the DCFH program were collected from fish entering the DCFH ladder and trap. Adult collection and spawning protocols at DCFH require systematic collection across the entire adult return period. The original Chinook salmon program guidelines targeted a release of 1 million Chinook salmon smolts sized at 50 fish per pound, to achieve the escapement goal of 1,750 returning adult Chinook salmon returning to the Russian River system. The program estimated a need to collect 1.3 million eggs and spawn a minimum of 333 females to achieve the production guidelines, and, generally, there was a desire to collect 1.5 to 2 times those numbers for male broodstock. If there were insufficient Russian River Chinook salmon to achieve the program egg take goals, it was acceptable to transfer late-run Chinook salmon eggs from the Eel River system to meet the goals. Additionally, when the numbers of available eggs were less than the target, it was acceptable to rear fish to the yearling size of 10 fish per pound in an effort to increase their post-release survival.

Between 1993 and 1998, the number of female Russian River Chinook salmon used as broodstock varied, in direct response to the number of adult fish returning to the hatchery (Table 3-26). The number of males used as broodstock during this period was not recorded in hatchery records, but has been estimated based on the general spawning protocols in effect at the time. During this period, any naturally-spawned Chinook salmon that voluntarily entered the traps were retained as broodstock whenever possible. The specific number of naturally-spawned adults used as broodstock is not known, but it has been stated that returning hatchery-reared individuals were the primary source of broodstock (R. Gunter, CDFG, pers. comm. 1999). The DCFH Chinook enhancement program was terminated in 1999.

Table 3-26 Chinook Salmon Broodstock Spawning Levels at DCFH from 1993 to 2003

Year[1]	Females (actual)[2]	Males (approx.)[3]
1993-1994	0	0
1994-1995	9	18
1995-1996	11	22
1996-1997	7	14
1997-1998	7	14
1998-1999[4]	0	0
1999-2000[4, 5]	NA	NA
2000-2001[4, 5]	NA	NA
2001-2002[4, 5]	NA	NA
2002-2003[4, 5]	NA	NA

1 Operating year for CDFG extends from July 1 of first year to June 30 of second year.
2 Data regarding females spawned compiled from DCFH annual reports.
3 Total number of males estimated by assuming spawning ratio of 2 males: 1 female (CDFG 2002).
4 Activities after the 1997- 1998 year are not part of the baseline.
5 The Chinook salmon enhancement program was terminated in 1999.

Rearing and Release

Incubation and fry-rearing functions for the DCFH Chinook salmon program were conducted inside the DCFH hatchery building. Approximately 6 weeks after hatching, it was typical to transfer the fry into outdoor concrete raceways. Fish reared for release as smolts (sized at 50 fish per pound) were released to Dry Creek in April or May. Fish reared to the yearling size (greater than 10 fish per pound) were typically released to Dry Creek in November.

Annual release data for the DCFH Chinook salmon program are presented in Table 3-27, including the total release number, pounds, and average size at release. The data reflect all releases that occurred between facility start-up through June 2003, even though the environmental baseline ends with the 1997 to 1998 year. Returns of Chinook salmon have never allowed adequate egg take to achieve the release goal of 1 million smolts. Comparison of relevant data on adult returns and egg harvest indicates that Chinook salmon release numbers were directly related to availability of broodstock, and low-release numbers should not be construed as a reflection of hatchery operations. Survival from unfertilized egg to stocked yearling routinely surpassed the management goal of 50 percent.

Hatchery-reared Chinook salmon generally migrate to the ocean at a larger size than their naturally-spawned smolt counterparts. This suggests that direct predation may occur if hatchery releases overlap natural production on either a spatial or temporal basis. At the same time, larger individuals may emigrate more quickly than smaller individuals, decreasing the risk of freshwater predation and competition.

Table 3-27 DCFH Chinook Salmon Release History

Year[1]	Fingerling			Yearling		
	Number	Pounds	Avg FPP[2]	Number	Pounds	Avg FPP[2]
1981-1982	102,360	2,160	47	0	0	0
1982-1983	68,750	2,083	33	20,900	3,074	7
1983-1984	66,120	1,740	38	0	0	0
1984-1985	211,510	4,697	45	0	0	0
1985-1986	884,520	18,595	48	0	0	0
1986-1987	92,765	1,835	51	34,592	3,225	11
1987-1988	54,150	1,275	42	0	0	0
1988-1989	237,450	6,800	35	0	0	0
1989-1990	13,770	270	51	36,037	3,837	9
1990-1991	0	0	0	0	0	0
1991-1992	113,525	2,525	45	0	0	0
1992-1993	8,877	269	33	0	0	0
1993-1994	0	0	0	50,300	4,800	10
1994-1995	0	0	0	0	0	0
1995-1996	0	0	0	25,923	13,000	2
1996-1997	0	0	0	31,990	10,000	3
1997-1998	0	0	0	7,800	750	10
1998-1999[3]	0	0	0	11,730	2,300	5
1999-2000[3, 4]	0	0	0	0	0	0
2000-2001[3, 4]	0	0	0	0	0	0
2001-2002[3, 4]	0	0	0	0	0	0
2002-2003[3, 4]	0	0	0	0	0	0
Avg - All Years	84,264	1,913	21	9,967	1,905	3
Avg - Releases	168,527	3,826	43	27,409	5,239	7

[1] The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
[2] Avg FPP = average size (fish per pound) at release.
[3] Releases made after the 1997-1998 year are not part of the baseline.
[4] The Chinook salmon enhancement program was terminated in 1999.

Rearing of all DCFH Chinook salmon used Lake Sonoma water, and releases occurred in Dry Creek approximately 3 miles downstream from the hatchery. Due to these rearing and release locations, all Chinook salmon were acclimated to a certain degree within the Russian River system, suggesting that straying to out-of-basin rivers is unlikely to be a great concern. Adult Chinook salmon would likely return to release streams rather than non-natal tributaries.

Adult Returns

Adult returns to the DCFH are presented in Table 3-28. During the 1980 to 1998 period when the Chinook salmon enhancement program was conducted, the maximum capture of adult Chinook salmon in the DCFH trap was 304 fish. It is unknown what harvest levels of Chinook salmon occurred during this period. It is unlikely that the escapement goal of 1,750 Chinook salmon to the mouth of the Russian River was ever achieved. It is suggested that the survival estimate of 0.175 percent stated in the DCFH management plan established optimistic and unrealistic adult escapement goals.

Table 3-28 History of Chinook Salmon Trapped at DCFH

Year[1]	Male	Female	Grilse	Total
1980-1981	0	0	0	0
1981-1982	0	0	0	0
1982-1983	1	0	0	1
1983-1984	2	1	1	4
1984-1985	7	1	0	8
1985-1986	65	0	0	65
1986-1987	50	25	36	111
1987-1988	176	4	124	304
1988-1989	151	61	21	233
1989-1990	8	6	3	17
1990-1991	67	0	32	99
1991-1992	77	46	2	125
1992-1993	15	22	3	40
1993-1994	8	0	13	21
1994-1995	59	9	17	85
1995-1996	18	12	3	33
1996-1997	25	11	7	43
1997-1998	16	14	19	49
1998-1999[2]	1	0	3	4
1999-2000[2, 3]	2	0	0	2
2000-2001[2, 3]	21	5	3	29
2001-2002[2, 3]	5	3	2	10
2002-2003[2, 3]	181	83	42	306
Average	**42**	**13**	**14**	**69**

1 The CDFG operating calendar extends from July 1 of the first year through June 30 of the second year.
2 Activities after 1997 to 1998 are not part of the baseline.
3 The Chinook salmon enhancement program was terminated in 1999.

Harvest Management

Fishing regulations would allow the take of hatchery-reared Chinook salmon (Chinook salmon releases are marked with clipped adipose fins), but the current lack of hatchery Chinook salmon production precludes the harvest of Chinook salmon within the Russian River basin. Harvest of naturally-spawned Chinook salmon is prohibited. While this strategy minimizes direct fishing mortality of Chinook salmon, indirect effects such as hooking mortality and harassment may still occur. There are no current estimates for incidental harvest levels of Chinook salmon within the Russian River.

Rearing for Out-of-Basin Programs

DCFH participates in an egg-banking program for a unique run of late fall Chinook salmon from the Eel River. Eggs from fall Chinook salmon spawned in the Eel River drainage are brought to the DCFH for incubation. At the time of spawning, adult fish used as the source of these eggs are tested for viral pathogens and screened for *Renibacterium salmoninarum*, the causative agent of bacterial kidney disease (W. Cox, pers. comm. 1999). Upon arrival at the DCFH, the Eel River eggs are disinfected with iodophore solution to remove surface pathogens that may be present. Egg lots are incubated separately until completion of viral certification, after which time the egg lots may be combined. When the eggs reach the eyed-egg lifestage, half are sent to Mad River Hatchery to continue incubation and rearing. The remaining eggs are kept at DCFH, reared to the juvenile stage, then returned to the Eel River where they are imprinted on Eel River water and released.

3.8.4 Factors Affecting Species Environment

Potential effects on listed coho salmon, steelhead, and Chinook salmon in the Russian River basin that may arise from the existing fish facility operations were evaluated in *Interim Report 2 Fish Facility Operations* (FishPro, Inc. and ENTRIX, Inc. 2000). Operating practices of the DCFH and CVFF facilities reflect a commitment to minimize effects on listed populations. Procedures for waste treatment demonstrate continuous compliance with recommended discharge standards for water quality. The facilities have been able to effectively manage routine fish diseases. Recent changes in policy regarding importation of stocks have resulted in minimal likelihood of effects on listed stocks due to disease. Similarly, current operations relating to production goals and harvest are the most practicable approach to minimizing ecological effects such as competition, predation, and overexploitation.

In general, there is a low risk of adverse effects to listed fish populations. Given the mixed stock history of DCFH and CVFF, adult salmonids currently returning to the facility may be of mixed origin. Therefore, the risk of outbreeding depression is potentially higher than would be the case had broodstock always been collected locally. Over the course of the Chinook salmon program at DCFH, the numbers of adult Chinook salmon returning to the hatchery was frequently low. As a result, the number of Chinook salmon spawned as broodstock was often below the generally-recommended minimum of 100 adult pairs, and therefore hatchery Chinook salmon may have incurred an unfavorable level of inbreeding. There is a low risk of artificial selection in the hatchery program because traditional rearing techniques are used and because naturally-spawned individuals are not used as broodstock. Hatchery production of steelhead may contribute to competition with naturally-spawned steelhead, and there is a low risk that hatchery fish may prey on listed naturally-produced fish because they are released at a larger size. However, steelhead releases are not generally made in primary spawning or rearing habitat, and the volitional release strategies employed at CVFF minimize these risks even further.

3.9 SUMMARY OF FACTORS AFFECTING SPECIES ENVIRONMENT

Potential effects to salmonid populations from SCWA and USACE activities in the Russian River can be grouped into several subcategories:

- Operational Effects
    - flow recessions
    - entrainment and impingement
    - impediments or barriers to outmigration
- Effects Related to Water Management
    - summer flows
    - winter flows
    - operation of the Wohler Inflatable Dam
- Channel Maintenance Activities
- Fish Production Facilities

Dam and water diversion facility operations may result in effects to juvenile salmonids, including stranding, entrainment, and impingement, and barriers to outmigration.

D1610 flow requirements are currently one of the primary factors affecting salmonid populations in the Russian River system. Flow (which determines water velocity and depth) is considered to be a key determinant in the quantity and quality of physical salmonid habitat in areas downstream of the dams. Flow also influences water quality parameters including temperature and DO, thereby affecting habitat quality. In the Russian River system, flows exert their effects primarily on the quantity and quality of summer rearing habitat available. During the winter months, project operations have a much lower effect on fish habitat, as flow levels are influenced primarily by runoff from unregulated tributary streams.

Fish production facility operations may also affect naturally-reproducing populations of listed fish species through competition, predation, and effects to genetic integrity. Other influences on salmonid populations are related to the presence of predatory species in areas of warmer, slow-moving water.

3.9.1 Operational Effects

Operation of various USACE and SCWA facilities in the Russian River system have the potential to affect listed fish species. Potential effects related to operations at Coyote Valley Dam and the Mirabel and Wohler diversion facilities are discussed below.

3.9.1.1 Flow Recessions

Coyote Valley Dam Inspection and Maintenance Activities

Ramping at higher levels of flow (greater than 250 cfs) during flood control operations holds less risk for stranding young fish than when flows are lower. Releases from the dam are decreased (ramped down) or cease during inspection and maintenance activities. Two issues arose in the evaluation of potential effects on juvenile salmonids: flow reduction during inspection and maintenance activities, and timing of inspections. When flows are decreased (ramped down) or cease, downstream habitat is subjected to flow recessions and dewatering. Stranding of juvenile salmonids has been documented. When inspections occur in the late winter/spring, fry (small fish are more susceptible) may be present. Under baseline conditions, the criterion for ramping-down releases from the dam when flows are less than 250 cfs is 50 cfs/hr.

Use of the current 50-cfs/hr ramping rate during pre-flood inspections and maintenance activities at Coyote Valley Dam does not provide protection from stranding for either fry or juveniles. Ramping effects may be observed in the East Fork and mainstem Russian River for several miles below the Forks. Coyote Valley Dam operations will not significantly affect listed species on the mainstem Russian River below the Forks during maintenance and inspection activities if there is sufficient flow at the Ukiah gage. However, lack of bypass flow capability may cause dewatering and stranding on the East Fork.

Coyote Valley Dam Flood Control Operations

Fish stranding may occur due to ramping down of streamflows during flood control operations at high reservoir releases (250 to 1,000 cfs) and at lower reservoir releases (less than 250 cfs). Fry and juveniles are most vulnerable to stranding during ramping due to their poor swimming abilities (Hunter 1992). However, the potential for stranding is low, given that there is generally considerable flow at the Forks from the mainstem Russian River to attenuate ramping effects. Often, flows are greater than 2,500 cfs at the Forks during flood operations ramp-down, and there is a backwater effect on the East Fork, which would attenuate stage changes (P. Pugner, USACE, pers. comm., 2000). Current operational conditions associated with interim ramping rates appear to provide adequate protection to listed species.

Mirabel Inflatable Dam

When the inflatable dam is raised or lowered, water levels downstream and upstream, respectively, of the dam can drop, creating an opportunity for stranding juvenile fish.

When the inflatable dam is lowered, flow recessions in approximately 3.2 miles of river upstream have the potential to result in stranding or displacement of salmonids. The risk of stranding is highest during a spring deflation of the dam because juvenile fish (including fry), which are more susceptible than larger fish, are more likely to be present. Several factors reduce this risk.

Generally, habitat in the 2-mile reach that is affected by impounded water above the inflatable dam does not have characteristics that increase the potential for stranding. When the inflatable dam is not inflated, the channel upstream of the dam is primarily run-habitat, with fine gravel, cobble, and boulder substrates. It is a single-channel river with a relatively straight trajectory through the area and relatively few structural features that would create low areas outside the main channel. The slopes of the river margins have a low gradient, which could increase the risk of stranding, but are sloped to the main channel. The wetted channel extends from bank to bank whether the dam is inflated or deflated, so dewatering of the riverbed is unlikely. Furthermore, the dam was lowered on average only 1.5 times per year over a recent 20-year period, and deflation usually occurs in the fall when small salmonids are less likely to be present. Deflation of the inflatable dam presents a low risk of stranding to juvenile salmonids if it is performed slowly enough.

Inflation of the dam usually occurs when river flows have declined from winter levels, generally in the spring. Although water may continue to spill over the dam during inflation, flow recessions occur downstream of the inflatable dam. Greater numbers of juvenile fish are likely to be present, and downstream habitat is more complex. Therefore, the risk of stranding young fish is higher.

3.9.1.2 Entrainment and Impingement

Operations of SCWA's diversion facilities at Mirabel and Wohler potentially result in impingement or entrainment of listed fish species. Fish may also be entrained in the infiltration ponds when flood flows overtop the levees.

The fish screens at the Mirabel diversion conform to most of the NOAA Fisheries screening criteria for protecting juvenile lifestages of salmonid species, but not fry. Coho salmon fry are generally found in tributaries rather than the mainstem, and therefore are at a very low risk. The timing of the Mirabel diversion operation normally does not overlap substantially with the juvenile outmigration period for Chinook salmon. There is a larger overlap with the diversion operation and juvenile steelhead outmigration period. Steelhead fry that may be present and early Chinook salmon downstream migrants may be at risk. However, the dam is generally inflated in mid-spring, when average fish lengths are beginning to be larger than fry-size.

The Wohler diversion system is considerably smaller than the one at Mirabel, but is ineffectively screened. When water is diverted to the Wohler infiltration ponds, fry and juvenile salmonids that are rearing or migrating through the area are at risk. Migrating juveniles of all three listed species, particularly steelhead, may be affected.

When flood flows overtop the infiltration ponds at Mirabel and Wohler, juvenile fish can be entrained. Because the Mirabel ponds overtop infrequently, migrating salmonids are at a low risk, and recent modifications for more effective fish-rescue efforts minimize this risk.

Prior to 1999, fry and juvenile salmonids could become trapped in the Wohler ponds when stormflows overtopped the levees surrounding the ponds. Because the Wohler ponds historically overtopped more frequently, migrating salmonids were at a higher risk of entrainment. While fish-rescue operations may have reduced the risk, some juvenile steelhead have been lost to injury or stress during rescue operations. Fish rescues were conducted after the levees overtopped, but at times they were delayed for up to 2 weeks until access was possible.

3.9.1.3 Impediments or Barriers to Outmigration

The Mirabel inflatable dam does not impede adult salmonid passage while lowered, and when in operation, the fish ladders are effective at passing adults of all species without delay.

The inflatable dam has been identified as a potential impediment to steelhead smolt outmigration (Manning et al. 2001, Manning 2003). When inflated, the dam at Mirabel impounds water for 3.2 miles upstream. This impoundment decreases current velocity, which has the potential to delay emigrating smolts. Data from SCWA's studies suggest that smolts that are physiologically prepared to emigrate experience a minor delay through the impounded area, but the delay seems to occur primarily at the dam. Recent studies by SCWA (Manning et al. 2001, Manning 2003) have shown that steelhead smolts tend to accumulate above the dam, but most fish pass successfully by swimming over the dam crest. Chinook salmon smolt emigration through the area does not appear to be delayed by the dam (Chase et al. 2002).

3.9.2 Effects Related to Water Management

Under D1610, flow levels are generally similar during the winter months to what they would be without the project. These flows are generally acceptable for the lifestages that occur during this time of year, including upstream migration, spawning, incubation, and emigration. During the summer and early fall months (June through October) the minimum instream flow requirements of D1610 have resulted in streamflows in the Russian River and Dry Creek that are dramatically higher than the natural flow regime. It is during this season that effects related to water management occur, primarily affecting summer rearing. These flows affect both the quality and quantity of rearing habitat due to the resulting velocities and depths, but also influence water temperatures.

3.9.2.1 Summer Flows

Based on the analyses of the effects of D1610 flows presented in *Interim Report 3* (ENTRIX, Inc. 2002b) and the results of the Flow/Habitat study conducted in the fall of 2001 (ENTRIX, Inc. 2003b, Appendix F), the flows occurring under D1610 at current demand levels results in velocities that are generally higher than optimal for juvenile salmonid rearing in most faster water sections of the upper Russian River and Dry Creek (i.e., riffle and run habitat types). However, a substantial amount of suitable rearing habitat remains in pools and along channel margins where velocities are more suitable. In *dry* water supply conditions, this situation is exacerbated in Dry Creek, as flows are increased to meet demand and to avoid dewatering Lake Mendocino. The flows in the upper Russian River are reduced, which would improve velocity conditions in that area.

Water temperatures under D1610 at current demand levels are generally acceptable for rearing in Dry Creek and the upper Russian River, but reach very stressful levels below Cloverdale. These water temperatures are such that they may preclude salmonid rearing during most of the summer. This occurs under both *all* and *dry* water supply conditions. Additionally, under *all* water supply conditions, the cold-water pool in Lake Mendocino may be depleted in September, which results in stressful temperatures in the upper Russian River during September and October.

Under the buildout demand levels, the additional water to meet the projected increased demand is provided from Lake Sonoma. Thus, flows in the upper and middle Russian River are similar to those under current demand levels, providing similar habitat conditions. Flows in Dry Creek are increased substantially, especially under *dry* water supply conditions, when they would more than double over current levels. This would result in much poor rearing conditions for juvenile salmonids in Dry Creek.

Temperatures under the buildout demand levels would remain similar in the Russian River, but would be lower and more favorable in the lower portion of Dry Creek. This improvement, however, is likely offset by the poorer habitat resulting from the higher water velocities at these flow levels.

The Estuary is important for adult and juvenile passage for all three listed species, and may provide important rearing habitat for steelhead and Chinook salmon. The current summer flow regime has the potential to affect several components of salmonid habitat in the Estuary. These include water quality (including temperature, DO, and salinity), primary productivity and the availability of aquatic invertebrates, availability of shallow water habitat, and the concentration of nutrients and toxic runoff. Augmented summer flow results in the need for an artificial breaching program that may also affect these components, and may allow adult Chinook salmon early access to the river when flows and temperature may be unsuitable.

Under D1610 flows, the sandbar that forms across the river mouth is breached several times in the summer/early fall, which creates fluctuating DO, temperature, and salinity conditions in the Estuary. Fluctuating salinity and low DO conditions decrease invertebrate populations upon which juvenile salmonids feed (ENTRIX 2002b). In addition, the current management plan results in the sandbar being open in the early portion of the migration period for Chinook salmon (late August and September). Thus, adult Chinook salmon can enter the river system before river conditions are suitable for upstream migration. The augmented flow in the Estuary may have several beneficial effects, including the dilution of agricultural and urban runoff and dilution of untreated waste from failing on-site sewage disposal systems throughout the watershed.

3.9.2.2 Winter Flows

Operations at Coyote Valley Dam and Warm Springs Dam regulate flood flows during winter storms. The dams moderate the naturally flashy conditions by reducing peak flows and maximum ramping rates. There are three issues related to potential effects on channel geomorphic conditions: scour of spawning gravels, streambank erosion, and channel maintenance/geomorphology. Sufficient flows should be available to maintain channel geomorphology for high-quality fish habitat, but high flows can scour spawning gravels and redds, as well as contribute to excessive bank erosion. Effects of flood control operations were evaluated in *Interim Report 1* (ENTRIX, Inc. 2000a).

The evaluation indicates that winter flows in the mainstem Russian River are sufficient to mobilize and flush spawning gravels, which maintains good quality spawning habitat. Flood control operations do not have a significant effect on spawning gravel scour in the Middle or Upper reaches of the Russian River. However, flows in Dry Creek below Warm Springs Dam can potentially be strong enough to scour redds and mobilize spawning gravels.

On the mainstem Russian River, potential effects of flood flows were evaluated for steelhead and Chinook salmon only, since coho salmon do not use the mainstem for spawning. The Upper and Middle reaches, between Ukiah and Alexander Valley, were included in the assessment. Downstream of Alexander Valley, spawning habitat is limited (Winzler and Kelly 1978, Cook 2003b), and flood control operations have a diminishing effect on high-flow conditions; the lower mainstem reach therefore was not considered for evaluation.

The evaluation indicates that stability of steelhead spawning gravels is very good in the upper mainstem reach. There is a moderate potential for scour of Chinook salmon gravels, but an acceptable balance between periodic streambed mobilization and spawning gravel stability. The lower incidence of scour of steelhead gravels compared with Chinook salmon gravels is at least partially due to the later-season incubation period for steelhead. During the steelhead incubation period, the incidence of flows that might scour spawning gravels is fairly low in the Upper Reach.

In the Middle Reach of the Russian River at Alexander Valley, spawning gravels are less stable and subject to slightly more frequent scour than the Upper Reach. The evaluation indicates moderately stable conditions for Chinook salmon, and moderately, but slightly less stable conditions, for steelhead. Higher discharges due to tributary flow accretion probably account for the greater incidence of scour in the Middle Reach compared with the Upper Reach.

On Dry Creek, effects of flood control operations were evaluated for coho salmon, steelhead, and Chinook salmon. There is a reasonably good balance between expected periodic streambed mobilization and spawning gravel stability for successful reproduction of Chinook salmon, and an acceptable balance for successful steelhead reproduction. Coho salmon, which use smaller gravels for spawning, would be subject to a greater frequency of scour than either steelhead or Chinook salmon redds.

3.9.2.3 Operation of the Wohler Inflatable Dam

Operation of the inflatable dam may slightly increase the risk of predation on migrating Chinook salmon or a few rearing steelhead. YOY steelhead have been found in the area, but not YOY coho salmon. The inflatable dam impounds water, resulting in an increase in pool habitat that has the potential to increase habitat for the warmwater fish community, including predators. This potentially increases the risk of predation on migrating juveniles. The ability of predators to consume juvenile salmonids depends on their relative sizes; larger predators are most likely to prey on young fish. Sampling in the Wohler Pool in 1999 through 2003 found predators (e.g., smallmouth bass) in vastly larger numbers in young-age classes than older-age classes. However, older, larger predators that can prey on young salmonids were found in very low numbers (Chase et al. 2003).

Temperature monitoring in both the impounded area and in the free-flowing river areas found favorable temperatures for warmwater predator populations. However, monitoring studies also found that the impoundment created by the inflatable dam was not responsible; water temperature increased only slightly (approximately 0.5°C) above water temperature upstream of the impoundment (Chase et al. 2002).

3.9.3 Channel Maintenance Activities

Interim Report 5 (ENTRIX, Inc. 2001b) identified several adverse modifications to salmonid habitat due to channel maintenance activities in constructed flood channels. These maintenance activities include sediment maintenance and vegetation maintenance.

Sediment maintenance in constructed flood control channels reduces fish passage to spawning and rearing habitat and restricts downstream migration. Most sediment maintenance occurs in channels in urbanized areas where low summer flows reduce water quality and there is poor summer rearing habitat. Therefore, sediment maintenance actions may have a substantial effect on passage in some channels where the streambed is flattened removing the thalweg. Direct effects to rearing habitat in the maintained portion of the channel are of lower concern.

Vegetation maintenance occurs in constructed flood control channels and, to a more limited extent, in natural waterways. The urbanized portion of the watershed in Santa Rosa and the Cotati-Rohnert Park areas contain most of the constructed flood control channels. Natural waterways and constructed flood control channels in the Rohnert Park area are generally low-gradient, run through a valley plain to the Laguna de Santa Rosa, and contain poor summer rearing habitat. The Laguna de Santa Rosa has important wetland and flood control functions for this part of the watershed. Santa Rosa Creek also drains to the Laguna de Santa Rosa, which, in turn, drains to Mark West Creek. Channel maintenance activities on constructed and natural waterways in this part of the Mark West Creek watershed, including the Santa Rosa Creek watershed, have the potential to affect coho salmon and steelhead because this area contains good rearing and spawning habitat for these species. Chinook salmon and steelhead may be affected in the Santa Rosa Creek watershed.

SCWA and MCRRFCD channel maintenance activities related to USACE obligations for flood control structures occur in Dry Creek and the mainstem Russian River in Sonoma and Mendocino counties. Loss of riparian vegetation due to maintenance of bank stabilization structures under USACE obligations on Dry Creek and the mainstem Russian River may have a moderate effect when shade canopy and cover are reduced.

SCWA and MCRRFCD have conducted activities in the mainstem of the Russian River related to streambank stabilization. These activities, as conducted under baseline practices, potentially have a substantial effect on populations of listed fish species because habitat in large amounts of river and stream channel can be altered. This is particularly true upstream of Asti in Mendocino County because some of the most valuable mainstem rearing and spawning habitat occurs there. Gravel bar grading and vegetation removal potentially affects listed fish species by reducing pool habitat formation and loss of high-flow refuge, as well as reducing shade canopy and cover.

3.9.4 Fish Production Facilities

Hatcheries may have adverse effects on listed fish species. Hatchery-bred fish may affect naturally-reproducing stocks through competition, predation, and changes in genetic integrity. Evaluation of hatchery operations in *Interim Report 2* (FishPro and ENTRIX, Inc. 2000) indicated that, in general, there is a low risk of adverse effects to listed fish.

Given the mixed stock history of DCFH and CVFF, adult salmonids currently returning to the facility may be of mixed origin. Therefore, the risk of outbreeding depression is potentially higher than would be the case had broodstock always been collected locally. Over the last 4 years of the Chinook salmon program, the numbers of female Chinook salmon returning to the hatchery decreased considerably, reflecting the shift to local broodstock rather than out-of-basin sources. The numbers of Chinook salmon spawned during that time was well below the suggested minimum of 100 adult pairs; therefore, hatchery Chinook salmon may have had an unfavorable level of inbreeding. There is a low risk of artificial selection in the hatchery program, because traditional rearing techniques are used and because the naturally-spawned individuals are not used as broodstock. Hatchery production of steelhead may contribute to competition with naturally-spawned steelhead, and hatchery fish may prey on listed natural fish because they are released at a larger size. However, steelhead releases are not generally made in primary spawning or rearing habitat, and the volitional release strategies employed at CVFF minimize the risk even further.

Operating practices of the DCFH and CVFF facilities reflect a commitment to minimizing effects on listed populations. The facilities maintain good track records on the ability to manage routine fish diseases, and recent changes in policy regarding importation of stocks have resulted in minimal likelihood of effects on listed stocks through disease. Current operations relating to production goals and harvest indicate that the best practicable approach is being utilized in minimizing ecological effects such as competition, predation, and overexploitation. Procedures for waste treatment demonstrate continuous compliance with recommended discharge standards for water quality.

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USACE, SCWA, and MCRRFCD will continue to implement many activities currently in place as described in Section 3, Environmental Baseline-Project. These agencies also propose modifications to existing operations to benefit listed salmonids within the Russian River watershed. The project will include both structural modifications to existing facilities and operational changes at the facilities.

This section focuses on the facilities and operations that would change relative to baseline conditions if the project is implemented. The project descriptions reference appropriate portions of Section 3 that will not change. This section is organized as follows.

Section 4.1 describes the modifications to flood control and the water storage facilities located at Lake Sonoma and Lake Mendocino. Operational changes include updates to the water control manuals, facility improvements at Warm Springs and Coyote Valley Dam for water supplies to fish production facilities, improved maintenance procedures during inspections and repairs.

Section 4.2 describes the modifications to the water diversion facilities at Mirabel and Wohler, and the transmission system that distributes the water. The descriptions of operations and maintenance identify changes intended to improve passage conditions at the diversions and minimize adverse effects to listed species.

Section 4.3, the flow management section, describes the proposed flow changes for the Russian River and Dry Creek (Flow Proposal). The objective of the Flow Proposal is to improve rearing conditions for salmonids in the Russian River, Dry Creek, and the Estuary. This section presents additional measures that SCWA is evaluating as part of the Flow Proposal. This section also describes the management of water levels in the Estuary with the goal of allowing the sandbar to remain closed during the summer months.

Section 4.4 describes the manner by which SCWA and MCRRFCD would conduct channel maintenance activities in the mainstem Russian River, constructed flood control channels, and tributaries. The proposed operations seek to balance habitat development and flood control.

Section 4.5 describes restoration actions that are being undertaken by SCWA since the signing of the MOU. These efforts include watershed management; riparian and aquatic habitat protection, restoration, and enhancement; and water conservation and recycling.

Section 4.6 describes the proposed operational and facility changes at the fish production facilities. The proposed operations implement a coho salmon conservation hatchery program, modify the steelhead mitigation program, and provide for a future Chinook salmon recovery program. The coho salmon program will function as an integrated recovery program and would include a captive broodstock program. The steelhead program would continue to be operated as an isolated harvest program under the existing production and release goals. No production of Chinook salmon is presently proposed; however, future monitoring may indicate that a Chinook salmon recovery program is warranted.

Section 4.7 identifies the agreements, permits, and other regulatory requirements that will require modification for the proposed project to be implemented. As discussed in Section 1.4, the proposed project is subject to a number of legal constraints and agreements. These agreements may constrain the extent to which, absent regulatory approvals and/or changes to the agreements, USACE and SCWA are able to implement conservation measures, reasonable and prudent measures, and conservation recommendations to be developed by NOAA Fisheries in the BO for the consultation. Therefore, implementation of the proposed changes may require modification or revision of the existing institutional agreements as well as compliance with NEPA and CEQA and other laws and regulations.

USACE and SCWA will also propose monitoring efforts to assess the effectiveness of the proposed actions on improving environmental conditions for listed salmonids, where appropriate. These will be developed in consultation with NOAA Fisheries and CDFG.

4.1 Flood Control, Water Storage, and Supply Operations

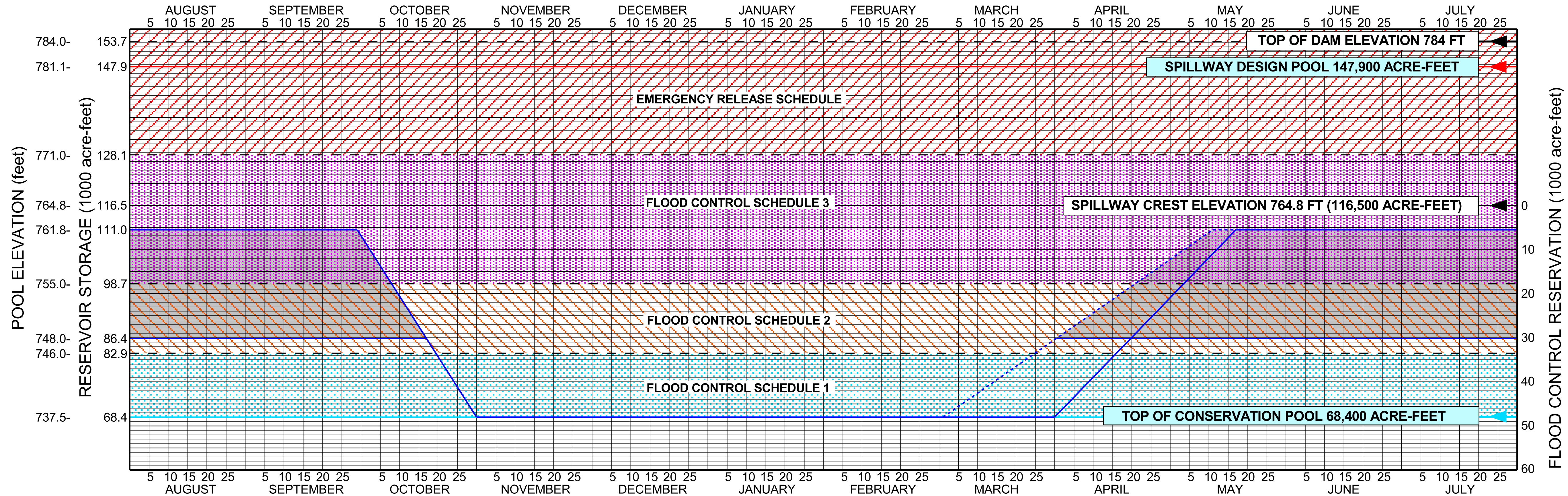
This section discusses proposed changes and upgrades to the physical components of the water storage and supply facilities.

Three major reservoir projects provide water supply storage for the Russian River watershed: Lake Pillsbury (Eel River), Lake Mendocino, and Lake Sonoma (Figure 2-1). Lake Pillsbury is part of the PVP, which is owned and operated by PG&E; its operations under the authorization of FERC are being addressed in a separate Section 7 Consultation between NOAA Fisheries and FERC (NMFS 2000a). Changes to the release criteria and minimum flow provisions in the 1983 FERC license for the PVP have been proposed by various parties, and are the subject of the BO from NOAA Fisheries and an EIS prepared by FERC. This BA does not propose any changes to the operation of the PVP, but incorporates in its analysis the PVID flow proposal evaluated by FERC in its BA.

4.1.1 Coyote Valley Dam and Lake Mendocino

Lake Mendocino's water supply pool capacity is approximately 69,000 AF[1]. SCWA will continue to manage releases made from the water supply pool. USACE will manage releases when the water level rises above the top of the water supply pool (seasonally at elevations between 737.5 and 748 feet above MSL) and into the flood control pool (Figure 4-1). USACE will continue to manage releases during annual inspections and during maintenance and repair of the Coyote Valley Dam Project. Following formal

[1]All storage volumes discussed in this report are the 1985 bathymetric survey values reported by SCWA.



RELEASE SCHEDULES

WATER SUPPLY SCHEDULE
As directed by the Sonoma County Water Agency

FLOOD CONTROL SCHEDULE 1, Pool elevations reached between 737.5 and 746.0 feet
Release up to a max of 4,000 cfs depending on antecedent ground conditions and time of year; subject to Limitations 1 thru 4, shown hereon.

FLOOD CONTROL SCHEDULE 2, Pool elevations reached between 746.0 and 755.0 feet
Release up to a maximum of 4,000 cfs subject to Limitations 1 thru 4, shown hereon.

FLOOD CONTROL SCHEDULE 3, Pool elevations reached greater than 755.0 feet
Release up to a maximum of 6,400 cfs subject to Limitations 1 thru 4, shown hereon.

EMERGENCY RELEASE SCHEDULE

Pool Elevation (feet)	Gate Releases (cfs)
764.8 - 771.0	0
771.0 - 771.3	800
771.3 - 771.5	1,700
771.5 - 771.8	2,500
771.8 - 772.0	3,300
772.0 - 772.3	4,200
772.3 - 772.5	5,000
772.5 - 772.8	5,800
772.8 - 773.0	6,600
773.0 and above	7,500 (gates 100% open)

LIMITATIONS

1. The rate of change for flood releases will be as follows when the pool elevation is at or below 764.8 ft:

Flow Range	Max Rate (cfs/hr) falling	Max Rate (cfs/hr) rising
minimum - <250	25	1000
250 - <1000	250	1000
1000 - 6400	1000	2000

2. When flow at the Russian River near Ukiah gage exceeds 2,500 cfs and is rising, flows in the Russian River will be monitored hourly so that reductions in releases from Coyote Valley Dam can be made to ensure dam operations will adhere to all other limitations and operating criteria.

3. Flood releases which contribute to flows greater than 8,000 cfs at the Russian River near Hopland gage, will not be made, insofar as possible. Also, releases will be limited to the discharge that results in flow at the Russian River near Hopland gage being less than that reached during the previous storm or storm series. The previous storm or storm series is defined as an event(s) separated by no more than 10 days, which caused the highest flow at the specified gage location above.

4. When the National Weather Service QPF is 1 inch or more for the next 24 hours or 1/2 inch or more for any 6-hour period in the next 24 hours, flows in the Russian River will be monitored hourly so that reductions in releases from Coyote Valley Dam can be made to ensure dam operations will adhere to all other limitations and operating criteria.

USE OF DIAGRAM

1. Releases from the lake will be made in accordance with the highest schedule reached during the current or previous storm or storm series, shown hereon, subject to the applicable limitations.

2. Depending on conditions prevailing at the time, the Corps of Engineers District may direct that flood releases be increased or decreased from those required by this diagram without requiring a deviation.

NOTES:

1. Gates may be used when the pool is above spillway crest (elevation 764.8 feet) for Flood Control Schedule 3 releases; however, the sum of the spill and the releases must not exceed 6,400 cfs (i.e. - outlet discharge is reduced as spillway discharge increases), and should not exceed Limitations 1 thru 4, shown hereon, to the extent possible.

2. The Corps of Engineers will reduce the flood control space on the 1st of March if it is determined the flood control functions of the project will not be impaired.

3. Normally, the summer pool elevation will be kept at 748.0 feet to maximize recreational opportunities at the lake; however, Sonoma County Water Agency retains the right to raise the summer pool elevation to 761.8 feet based on demonstrated demand and NEPA criteria being met.

4. Pertinent reservoir pool elevations correspond to the following reservoir storages:

737.5 ft	68,400 acre-feet	Top of Conservation Pool
746.0 ft	82,900 acre-feet	
748.0 ft	86,400 acre-feet	Summer Pool
755.0 ft	98,700 acre-feet	
761.8 ft	111,000 acre-feet	
764.8 ft	116,500 acre-feet	Spillway Crest
771.0 ft	128,100 acre-feet	
781.1 ft	147,900 acre-feet	Spillway Design Pool
784.0 ft	153,700 acre-feet	Top of Dam

Developed by PEP/BJA - Prepared by JSM

COYOTE VALLEY DAM - LAKE MENDOCINO
RUSSIAN RIVER, CALIFORNIA

WATER CONTROL DIAGRAM

U.S. ARMY CORPS OF ENGINEERS
SAN FRANCISCO DISTRICT
(Water Management by Sacramento District)

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notification from USACE to SCWA of planned inspections or maintenance, SCWA will notify the SWRCB. USACE will notify NOAA Fisheries directly of the planned work. The Coyote Valley Dam facilities (and current operations) are described in Section 3.1.

4.1.1.1 Flood Control Operations of Coyote Valley Dam

USACE's primary objective for flood control releases from Lake Mendocino is to continue to prevent flood flows on the East Fork Russian River from contributing to overbank flood stages on the Russian River below Coyote Valley Dam. To the extent possible, USACE will limit releases from Lake Mendocino to prevent local flooding at Hopland, which generally occurs when flows in the Russian River exceed 8,000 cfs. Because bank sloughing is likely to occur when flows decrease too rapidly, USACE will limit the reduction in releases from Lake Mendocino to 1,000 cfs/h or less. Winter operations will include storage until the dedicated flood storage space is reached and flood control releases are made, as described below.

The specific criteria for Coyote Valley Dam flood control operations were revised in Exhibit A of the Water Control Manual (USACE 2003a). The general criteria for releases from the flood control pool, which includes all reservoir storage above the top of the water conservation pool, call for successively increasing releases in three stages as reservoir levels rise toward the emergency spillway. The operations provide for the greatest monthly reductions in lake level during late spring and early summer. When possible, releases from Coyote Valley Dam will be controlled so that flow at Hopland, approximately 14 miles downstream, does not exceed the 8,000-cfs channel capacity. However, maintaining flows of 8,000 cfs or lower at Hopland is not possible when inflow to Lake Mendocino is very high.

Specific directions for flood control operation are described by the Flood Control Diagram included in Exhibit A of the Water Control Manual, entitled "Standing Instructions to Damtenders" (Coyote Valley Dam Standing Instructions) as follows:

> *Flood Control Schedules 1, 2, and 3 releases are used to empty the flood control space following a storm. Under these schedules, releases will be limited to: (1) the discharge that does not cause the flow at the Russian River near Hopland to exceed 8,000 cfs, and (2) the discharge that results in flow at Hopland being less than that reached during the previous storm or storm series. The previous storm or storm series is defined as the event or events, which caused the highest pool at Lake Mendocino. In addition, releases will be limited to (1) up to 4,000 cfs if the reservoir pool did not reach elevation 746.0 feet, (2) 4,000 cfs if the highest reservoir pool reached was between elevation 746.0 feet and 755.0 feet, and (3) up to a maximum of 6,400 cfs if the pool exceeded elevation 755.0 feet. Releases will not be increased or decreased at a rate greater than 1,000 cfs per hour. Schedules 1, 2, and 3 are used if no significant rainfall is predicted.*

When the QPF is 1 inch or more for the next 24 hours or 1/2 inch or more for any 6-hour period in the next 24 hours, and releases exceed 1000 cfs, flows in the Russian River will be monitored, to ensure dam operations adhere to all other limitation and operating criteria. Also, when the flow in the Russian River at Ukiah exceeds 2,500 cfs and is rising, releases from Lake Mendocino will be reduced to 25 cfs, insofar as possible.

Outlet gates may be used for Flood Control Schedule 3 releases when the pool is above the spillway crest (elevation 764.8 feet); however, the sum of the spill and the releases must not exceed 6,400 cfs, subject to the above limitations.

The Emergency Release Schedule is used between elevation 764.7 feet and 773.0 feet, at which stage the flood control gates are fully opened. The flood control gates will remain fully open until the reservoir pool has receded to elevation 764.7 feet, at which time the release schedule 3 is implemented.

4.1.1.2 Coyote Valley Dam Maintenance and Inspection Activities

Annual and periodic (5-year) pre-flood inspections, as described in Section 3.1, would continue for the Coyote Valley Dam facilities. In the evaluation of the potential effects of maintenance and inspection activities, two issues arose: timing of inspections, and flow reduction during inspections and maintenance activities. To address these issues, structural modifications would be made at the dam, and changes in timing and operations during inspection and maintenance would be implemented.

Annual and periodic (5-year) inspections at Coyote Valley Dam typically require that flows through the dam cease for approximately 2 hours. Implementation of periodic maintenance or repairs identified during inspections may require flows through the dam to be reduced or shut down for longer periods, from 1 hour to several days. In the past during such inspections, the East Fork Russian River has been subjected to dewatering, and flows have been reduced in the Russian River downstream of the confluence with the East Fork.

To avoid dewatering the East Fork, USACE proposed to modify the Coyote Valley Dam facilities to allow a bypass flow of 25 cfs during inspection and maintenance. USACE is evaluating the installation of two pumps, approximately 250 hp each, to provide approximately 25-cfs flow in the East Fork Russian River. The bypass pumps would be attached to the outside of the control tower at Coyote Valley Dam and would draw water directly from the reservoir. The water would pass through a small pipeline and would be discharged downstream of the weir below the dam. USACE anticipates incorporating the bypass pipeline into the bridge to the control tower. The pumps will be operated as independent systems, thereby maintaining flow if one of the pumps fail. The pumps would remain operating during maintenance and inspection activities. This action would provide an uninterrupted flow of good quality water when the pumps are operating.

Construction of the bypass pipeline would provide a reliable water supply to the CVFF located at the base of the dam. A 15-cfs release from the bypass pipeline would be provided to supply water during maintenance activities or emergency repairs if the fish facility is in operation.

In 1998 and 1999, inspections at Coyote Valley Dam took place in September and June, respectively. In 2000, pre-flood inspection took place in May. During inspections, flows must be reduced or completely shut down. During previous inspections, flow interruption has affected young salmonids in the East Fork and the portion of the mainstem just below the confluence with the East Fork. To minimize the potential for routine maintenance and inspections to negatively affect salmonid fry, USACE will conduct such activities when young salmonid fry are not likely to be abundant. USACE proposes to schedule routine maintenance and inspection activities between July 15 and October 15. Shifting routine inspection and maintenance work to avoid May and June would allow the young salmonids in the reaches potentially affected to grow to a larger size so they are better able to avoid being stranded during declining flows.

4.1.1.3 Ramping Rates

Flows are ramped down during flood releases and in preparation for maintenance and inspection conducted in the summer and fall. USACE developed interim guidelines for flow release changes in consultation with NOAA Fisheries and CDFG described in Table 3-1. The evaluation of ramping rates for Coyote Valley Dam provided in *Interim Report 1* (ENTRIX, Inc. 2000a) indicated that protection of young salmonids could be improved if ramping rates for flows below 250 cfs were modified (ENTRIX, Inc. 2000a). Under the proposed operations, USACE proposes to modify the ramping schedule for Coyote Valley Dam and change the outlet structure to allow greater control over the gate opening. When releases from Coyote Valley Dam are less than 250 cfs, the ramping rates during decreasing releases would be reduced to 25 cfs/h (Table 4-1). To improve the ability to regulate flow changes of this level, USACE would install new automated controls to facilitate closing the outlet gates to meet the proposed ramping rates.

Table 4-1 Coyote Valley Dam Ramping Rates

Reservoir Outflow	Proposed Ramping Rates
0-250 cfs	25 cfs/h
250-1,000 cfs	250 cfs/h
>1,000 cfs	1,000 cfs/h

4.1.2 Warm Springs Dam and Lake Sonoma

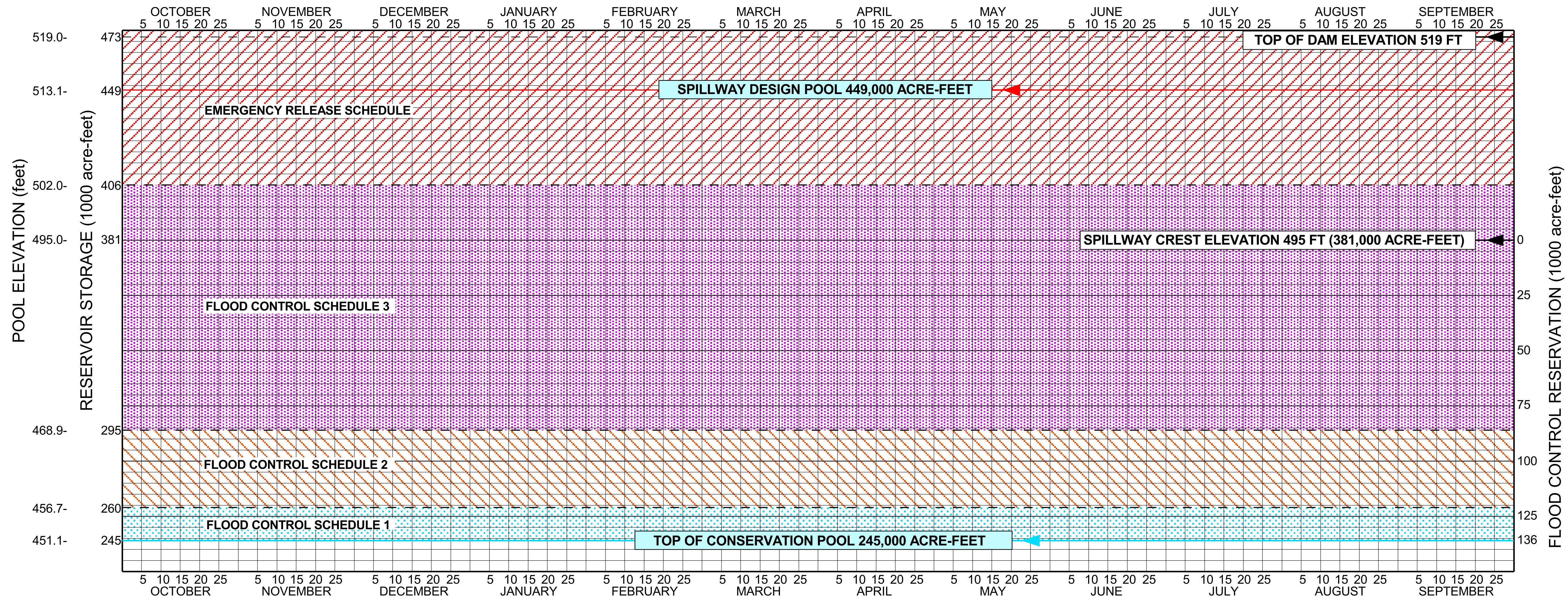
Lake Sonoma is located at the confluence of Warm Springs Creek and Dry Creek, approximately 10 miles northwest of the City of Healdsburg (Figure 2-1). Existing Warm Springs Dam facilities are described in Section 3.2. The water control diagram for Lake Sonoma is presented in Figure 4-2.

4.1.2.1 Flood Control Operations of Warm Springs Dam

USACE will continue to determine water releases when the water level rises above the top of the water supply pool (an elevation of 451.1 feet above MSL) and into the flood control pool. USACE also manages releases during annual inspections and during maintenance and repair of the project. SCWA will continue to manage releases made from the water supply pool. To the extent possible, USACE limits releases from Lake Sonoma to restrict flows on the Russian River at Guerneville to 35,000 cfs, which is the approximate channel capacity in Guerneville. USACE also limits releases to prevent flooding downstream along Dry Creek, which generally occurs when flows just below the dam exceed 6,000 cfs. The criteria for flood control operation of Lake Sonoma are similar to those for Lake Mendocino, and were revised in the Warm Springs Dam Water Control Manual (USACE 2003b). Releases from the flood control pool include all reservoir storage higher than an elevation of 451.1 feet above MSL. As with Lake Mendocino, flood control includes three successive flood release schedules. For Lake Sonoma, the Hacienda Bridge gage, located approximately 16 miles downstream of Warm Springs Dam, is the most downstream monitoring point for decisions affecting flood control releases from Lake Sonoma.

Specific directions for flood control operation are described by the Flood Control Diagram included in Exhibit A of the Warm Springs Dam Water Control Manual, entitled "Standing Instructions to Damtenders" (Warm Springs Dam Standing Instructions) as follows:

> *Flood Control Schedule 1, 2, and 3 releases are used to empty the flood control space following a storm. Under these schedules, releases will be limited to: (1) the discharge that does not cause the flow at Dry Creek near Geyserville gage (Yoakim Bridge) to exceed 7,000 cfs and/or flow at the Russian River near Guerneville gage to exceed 35,000 cfs, and (2) the discharge that results in flow at Guerneville being less than that reached during the previous storm or storm series. The previous storm or storm series is defined as the event or events that caused the highest pool at Lake Sonoma. In addition, releases will be limited to a maximum of: (1) 2,000 cfs if the reservoir pool did not reach elevation 456.7 feet, (2) 4,000 cfs if the highest reservoir pool reached was between elevation 456.7 feet and 468.9 feet, and (3) 6,000 cfs if the pool exceeded elevation 468.9 feet. Releases will not be increased or decreased at a rate greater than 1,000 cfs per hour. When the pool elevation is at or below 502.0 feet and inflow is at or above 5,000 cfs no gate releases will be made. Schedules 1, 2, and 3 are used only if no significant rainfall is forecasted.*
>
> *Rain forecasts are considered significant when the QPF is 1 inch or more for the next 24 hours or ½ inch or more for any 6-hour period in the next 24 hours and releases exceed 1,000 cfs, flows in Dry Creek and the Russian River will be monitored hourly so that reductions in releases from Warm Springs Dam can be made to ensure dam operations will adhere to all other limitations and operating criteria.*



RELEASE SCHEDULES

WATER SUPPLY SCHEDULE
As directed by the Sonoma County Water Agency

FLOOD CONTROL SCHEDULE 1, Pool elevations reached between 451.1 and 456.7 feet
Up to a maximum of 2,000 cfs subject to Limitations 2-4

FLOOD CONTROL SCHEDULE 2, Pool elevations reached between 456.7 and 468.9 feet
Up to a maximum of 4,000 cfs subject to Limitations 2-4

FLOOD CONTROL SCHEDULE 3, Pool elevations reached between 468.9 and 502.0 feet
Up to a maximum of 6,000 cfs subject to Limitations 1-4

EMERGENCY RELEASE SCHEDULE

Pool Elevation (feet)	Gate Releases (cfs)
502.0 - 502.3	800
502.3 - 502.6	1,600
502.6 - 502.9	2,400
502.9 - 503.2	3,100
503.2 - 503.6	3,800
503.6 - 503.9	4,600
503.9 - 504.3	5,300
504.3 - 504.7	6,000
504.7 - 505.0	7,000
505.0 and above	7,900 (gates 100% open)

NOTES:

1. Gates may be used when the pool is above the spillway crest (elevation 495.0 ft) for Flood Control Schedule 3 releases; however, the sum of the spill and the releases must not exceed 6,000 cfs (i.e. - outlet discharge is reduced as spillway discharge increases), and should not exceed Limitations 1-4, shown hereon, to the extent possible.

2. Pertinent reservoir pool elevations correspond to the following reservoir storages:

292.0 ft	20,000 acre-feet	Top of Minimum Pool
451.1 ft	245,000 acre-feet	Top of Conservation Pool
456.7 ft	260,000 acre-feet	
468.9 ft	295,000 acre-feet	
495.0 ft	381,000 acre-feet	Spillway Crest
502.0 ft	406,000 acre-feet	
513.1 ft	449,000 acre-feet	Spillway Design Pool
519.0 ft	473,000 acre-feet	Top of Dam

LIMITATIONS

1. Prior to releases above 5,000 cfs, appropriate personnel must be available and onsite to monitor the releases to ensure no damage to the EWSL pipeline will occur.

2. The rate of change for flood releases will be as follows when the pool elevation is at or below 502.0 ft:

Flow Range	Max Rate (cfs/hr) falling	Max Rate (cfs/hr) rising
minimum - <250	25	1000
250 - <1000	250	1000
1000 - 6000	1000	2000

3. When the lake pool elevation is at or below 502.0 ft, in so far as possible, no flood releases will be made which will (a) cause flow at the Dry Creek near Geyserville gage (Yoakim Bridge) to exceed 7,000 cfs and/or flow at the Russian River at Guerneville gage to exceed 35,000 cfs or (b) exceed flows reached during the previous storm or storm series. The previous storm or storm series is defined as an event(s) separated by no more than 10 days, which caused the highest flow at the specified gage locations above.

4. When the National Weather Service QPF is 1 inch or more for the next 24 hours or 1/2 inch or more for any 6-hour period in the next 24 hours, and releases exceed 1,000 cfs, flows in Dry Creek and the Russian River will be monitored hourly so that reductions in releases from Warm Springs Dam can be made to ensure dam operations will adhere to all other limitations and operating criteria.

USE OF DIAGRAM

1. Releases from the lake will be made in accordance with the highest schedule reached during the current or previous storm or storm series, shown hereon, subject to the applicable limitations.

2. Depending on conditions prevailing at the time, the Corps of Engineers District may direct that flood releases be increased or decreased from those required by this diagram without requiring a deviation.

Developed by PEP/BJA - Prepared by JSM

WARM SPRINGS DAM - LAKE SONOMA
RUSSIAN RIVER, CALIFORNIA

WATER CONTROL DIAGRAM

U.S. ARMY CORPS OF ENGINEERS
SAN FRANCISCO DISTRICT
(Water Management by Sacramento District)

Revised Jan 2004

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Flood Control Schedule 3 releases will be maintained until elevation 502.0 feet is reached. This is done by regulation the outlet so that the combined flow from spills (pool above elevation 495.0 feet) and releases through the outlet works does not exceed 6,000 cfs.

The Emergency Release Schedule is used about elevation 502.0 feet (153.0 m) at elevation 505.0 feet (153.9 m) the flood control gates will be fully opened.

4.1.2.2 Water Supply to Fish Facilities

Several engineering options are being considered to provide a more consistent supply of water to the DCFH. The existing water supply pipeline could be replaced with an engineered pipeline incorporated into the wall of the flood control outlet works. Alternatively, a pipeline stub could be installed in the wet well, exiting the left abutment near the existing tunnel. This pipeline stub would allow water to be tapped directly from the wet well for hatchery supply, and for other future uses (e.g., hydroelectric operations, water supply).

Water released from Lake Sonoma can be taken from four different intake portals, each at a different elevation in the lake. Three intake portals are located in the left abutment of the dam, while the fourth portal is located near the bottom of the reservoir. Water from different portals will be mixed to optimize water temperature, DO levels, and turbidity. The selection of water intake levels will be determined by USACE in coordination with DCFH to meet the water quality needs of the fish production facility. This will control the water quality of releases to Dry Creek as well. With implementation of the Flow Proposal, there may be times when all of the flow released to Dry Creek will first flow through the fish production facility.

Under baseline conditions, the uppermost intake was plugged with concrete. The plug was removed in 2002 and the intake was flushed in 2003 (P. Pugner, pers. comm. 2003). Since this upper water discharge intake was repaired and cleaned, there has been more flexibility in meeting water quality requirements at the DCFH and in Dry Creek.

4.1.2.3 Maintenance and Inspection Activities

The maintenance and inspection activities at Warm Springs Dam, described in Section 3.2, would continue. The changes in timing and ramping rates described in Section 4.1.1.3 would be implemented for inspection at Warm Springs Dam. When releases from the dam are less than 250 cfs, they will be ramped down at 25 cfs/h or less. A bypass flow of 25 cfs will continue to be provided during maintenance and inspection activities.

4.1.2.4 Hydroelectric Operations

The hydroelectric facility operations are described in Section 3.2.4. The hydroelectric facility operates using water supply releases. The reductions in releases from Warm Springs Dam (as described in Section 4.3) would reduce the quantity of hydroelectric generation. The minimum operating flow for the facility is 70 cfs. Implementation of the

Flow Proposal would require the concurrence of FERC, and modifications to the terms and conditions of the FERC license for Project No. 3351-002 (see Section 4.7.2).

4.2 Diversion Facility Operations

4.2.1 Diversion Facility Operations

Under the proposed project, SCWA would continue to divert and deliver water to its customers through the water transmission system. SCWA's diversion facilities are located near Wohler and Mirabel, on SCWA property. SCWA operates five Ranney collector wells and seven conventional wells adjacent to the Russian River, which extract underflow from the aquifer beneath the streambed. A sixth Ranney collector well, located in the Wohler area, is expected to begin operation in 2004. SCWA operates five infiltration ponds near Mirabel and two infiltration ponds near Wohler. The ponds recharge the aquifer to create a reliable water supply to the Ranney collector wells.

4.2.1.1 Mirabel Diversion Facility Modifications and Operation

The Mirabel diversion facilities (located at RM 24.6), include an inflatable dam and concrete foundation, an intake structure equipped with two rotating fish screens, a pump caisson and control structure, conveyance piping, an outlet structure, and two Denil fish ladders at opposing sides of the river. These facilities are described in Section 3.3. *Interim Report 4* identified several areas where the Mirabel diversion facilities and operations could be improved (ENTRIX, Inc. 2001d). The operational changes would be associated with ramping rates during dam inflation and facility improvements to the fish screens, outlet, fish ladders, and inflatable dam. Modifications to the inflatable dam and diversion facility would be undertaken to reduce the potential for entrainment and impingement of listed species, and to speed outmigration of smolts.

Water Diversion Operations at Mirabel

Water diversion operations would generally continue according to previous practices. SCWA relies on the operation of the inflatable dam and the Mirabel and Wohler facilities to meet the water demand for water supplies. The inflatable dam will continue to be operated at the Mirabel diversion facility to raise the water level in the river, increase the rate of aquifer recharge, and facilitate the diversion of water into the infiltration ponds.

Inflatable Dam

Operations of the inflatable dam would continue as described in Section 3.3, with several modifications to improve passage of downstream migrants through the Mirabel diversion and to reduce the opportunity for stranding young salmonids either upstream or downstream of the dam as the facility is raised or lowered.

The inflatable dam is typically raised in May and lowered in October-November (Table 3-3). Depending on water supply conditions, the dam may be raised as early as March, and lowered as late as January. As demand increases under projected future demand, these facilities will be increasingly relied upon to meet peak demands in the spring and fall months as well as the summer period. When inflated, the dam impounds water for approximately 3.2 miles (5.1 km) upstream, creating the Wohler Pool. The increased pressure head and wetted area result in increased recharge to the underlying aquifer.

When the inflatable dam is raised, water levels below the structure can drop, potentially stranding juvenile fish in the channel downstream of the structure. Studies would be conducted to determine the operations at Mirabel that would be protective of juvenile salmonids in the channel affected by reduced flow levels. Monitoring would continue to be conducted during inflation and deflation of the dam to determine the most appropriate rate and to assess the risk of stranding on juvenile fish. The rate of flow reduction downstream of Mirabel would depend on the ability to regulate the inflation of the dam and on observations of stage changes and an assessment of stranding potential in the Russian River downstream of the dam. SCWA will evaluate the effects of ramping rates on downstream habitats and develop ramping criteria that are feasible and safe. Due to the potential for serious injury to dam operators or recreational users during inflation or deflation activities, the duration of these activities will be minimized.

The shape of the inflatable dam would be modified to reduce the risk of delay during downstream migration for juvenile salmonids. A single depression would be created in the crest of the Mirabel inflatable dam to concentrate the flow of water over the dam. This depression would be in place during juvenile salmonid outmigration periods, and would be maintained until smolt outmigration is complete (through June 15). The depression would then be removed and the dam raised to its full height to achieve maximum infiltration.

The depression will provide a localized point of discovery for fish trying to move over the dam. It will be created by filling the bladder to a base elevation with water and then introducing pressurized air into the bladder. The depression will provide a direct pathway for outmigrating juvenile salmonids to pass over the dam and move downstream, and thereby reduce potential downstream migration delay through the Mirabel facilities.

Intake Facility and Fish Protections

The Mirabel intake structure and fish screens are located on the west bank of the Russian River. They will be reconfigured to comply with NOAA Fisheries and CDFG criteria to provide a screen configuration that prevents impingement and entrainment of fry and juvenile salmonids. The modified intake structure would likely include flat plate screens and mechanisms for adjusting the relative magnitudes of the approach and sweeping velocities to enable fry and juveniles to swim past the screens and avoid impingement. The intake screen structure would be connected to the existing fish ladder downstream of the proposed screen bank. By directing both diversion flow and fish ladder flow through a single structure, the flows would produce sweeping velocities parallel to the screen face that meet NOAA Fisheries criteria. The combined flow would also make it easier for outmigrating smolts to find their way to the fish ladder. The proposed changes, including preliminary engineering drawings, are described in Borcalli & Associates (2001).

The modified intake structure would provide a transport velocity of approximately 2 fps at the upstream end and, with a minor deceleration over the length of the screen, would have a fish ladder exit velocity of 1.33 fps. These transport velocities would limit juvenile exposure time along the screen bank to less than 60 seconds.

The vertical plate fish screen panels would be integrated into the modified intake structure and fish ladder. The screens will be constructed of wedge-wire with a 50 percent open area. The screens would be cleaned using an electrically-operated, traveling brush system that traverses the entire screen bank in both directions. This operation would assist in transporting debris outside the limits of the screen array. The total screen surface area provided would be roughly 450 square feet, 25 percent greater than that required to satisfy the NOAA Fisheries' fish screen criteria for a maximum approach velocity of 0.33 fps. The additional surface area would provide a margin of safety to avoid violation of approach velocity criteria.

Articulating porosity control baffles would be installed in the modified intake structure immediately behind or downstream of the screen panels. The baffles would provide an adjustable means of velocity control with respect to individual, predetermined depth ranges to ensure that localized areas of high velocity would not occur at the screen face. The baffles would require a one-time adjustment and periodic cleaning. The baffle adjustment would be checked each time the dam is raised and inspected annually after the dam has been deflated.

Fish Ladders

The Denil-style fish ladders installed on each side of the dam will continue to be operated when the dam is raised (see Section 3.3). The fish ladder on the western side of the dam would be integrated into the diversion structure, as discussed in the preceding paragraphs.

Under previous operations, still water created at the upstream entrance to the east ladder may have inhibited the use of the ladder by outmigrating salmonids. Based on preliminary observations in 2002, it appears that the effect of the still water may be ameliorated by the depression in the center portion of the dam (D. Manning, pers. comm. 2003). However, if the still water behind the dam continues to create an impediment for downstream passage through this ladder, the upstream end of this fish ladder would be modified to direct outmigrating salmonids toward it. This would be accomplished by moving the upper end of the eastern fish ladder closer to the dam, or by installing a buoyed curtain to exclude juvenile salmonids from the pocket of still water that develops behind the dam. In addition, SCWA plans to modify the east-side bypass pipeline so that it can be operated at its 22-cfs capacity without creating turbulence at the mouth. The west-side bypass pipeline and fish ladder currently function properly.

4.2.1.2 Wohler Diversion Operations and Facilities Modification

The Wohler ponds are an important component of the aquifer recharge system. During part of the year, surface water would continue to be diverted into the two Wohler infiltration ponds to increase water production. The ponds can only be filled when the

Mirabel inflatable dam raises the river water surface. *Interim Report 4* identified the potential for listed salmonids migrating downstream to be entrained in the diversion to the Wohler ponds or entrapped in the ponds when the levees are overtopped during storm events (ENTRIX, Inc. 2001d). Modifications to the Wohler ponds would be completed to reduce potential entrapment or stranding of anadromous fish, and to prevent entrainment and impingement during the diversion season.

The Wohler diversion facilities consist of two ponds, each independently connected to the Russian River by earthen canals. These canals would continue to function as both inlet and outlet to the ponds. When the Mirabel inflatable dam is raised and the level of the river surface is increased, the ponds can be filled by opening the slide gates. Additional facilities would be constructed at Wohler to provide better protection against entrainment and stranding of listed salmonids in the infiltration ponds. Additional facilities include new intake structures and new fish screens. Modifications of facilities include recontouring of the ponds to reduce the opportunity for fish stranding and promote drainage to the river.

Since 1999, two interim measures have been implemented: 1) the culverts leading to the ponds are temporarily screened with 3/32-inch punch plates when the infiltration ponds are filled during the summer months, and the screens are removed when the Mirabel inflatable dam is lowered; and 2) Ponds 1 and 2 are graded to allow the water to drain back toward the inlet pipe as water levels recede. As a result of these interim measures, fish rescues have been concentrated in a much smaller area. Although fish rescues are sometimes still conducted, no fish rescues were required in 1999 or 2000. These interim measures would continue to be implemented until the Wohler intake structures and fish screens are modified.

Wohler Intake Structures

New, permanent, reinforced-concrete intake structures would be constructed at the terminus (river end) of the intake canals (Borcalli & Associates 2002). The intake structures would be constructed when the ponds are empty and prior to raising the inflatable dam. The intake structures would facilitate installing and removing the proposed screen modules (described below), and would allow for permanent attachment of the slide gates. The intake structures would be sized to accommodate the screen area required to meet screening criteria. They would be keyed into competent foundation material and would include riprap revetments to maintain stability and soil/structure integrity. The structures would include concrete decks to catch debris removed from the screen face and facilitate its removal and disposal. In addition, the decks would provide all-weather access for gate operation.

Fish Screens

Removable, pre-assembled, self-cleaning fish screen modules would be designed and installed in accordance with NOAA Fisheries and CDFG fish screen criteria. The screen modules could include a self-contained, stainless steel framework; electro-mechanical brush-cleaning systems; and a permanent support infrastructure attached to the intake structures for simple removal and installation. Since the Wohler diversion facilities are located at the ends of their respective side channels, and because there is no practical means of providing bypass flows, sweeping velocities would not exist at the faces of the screens. NOAA Fisheries' fish screen criteria sets forth minimum sweeping velocities; however, in cases such as this one where still water conditions exist, it is not possible to provide sweeping velocities. The screens would be sized to provide sufficient protection for fry and juvenile fish. The surface area of the screens would be increased (4 to 5 times the required area) to reduce approach velocities well below NOAA Fisheries criteria. These low approach velocities would make it easy for juvenile fish to avoid impingement on the screens.

Power to operate the screen-cleaning apparatus would be provided from the adjacent pump houses. The fish screens would be installed each year before raising the Mirabel inflatable dam. When the ponds are no longer needed to provide increased infiltration and the inflatable dam is lowered, the fish screens would be removed and the ponds drained.

Recontouring Wohler Ponds

One of the concerns associated with the Wohler ponds is the opportunity for salmonids to become trapped when winter storm flows overtop the levees. Under the proposed project, Wohler Ponds 1 and 2 would be regraded each year so that they have minimal residual volume when drained. The ponds would be regraded to drain towards the inlet pipe, thereby directing any fish present out of the pond. Interim measures completed in 1999 involved the regrading of Pond 2. Pond 1 was regraded in 2000. In addition, during the wet season, the slide gates to the ponds would be left fully open to allow water to drain from the ponds back to the river and to allow salmonids washed into the ponds to escape.

In the past, fish rescues have reduced the potential effects associated with entrapment. Fish rescue operations would continue by wading the ponds with beach seine nets after pond levels drop to a depth where wading is possible.

Regrading the ponds would reduce, but likely would not eliminate, the necessity of conducting fish rescue operations for juveniles. Furthermore, by limiting rescues to a smaller, shallow area, fish rescues could be conducted more effectively, reducing potential stress to fish. As a result of the regrading of Ponds 1 and 2 and improved interim fish screens, fish rescues were minimized during 2000 and 2001 (S. White, SCWA, pers. comm. 2002b). Fish rescues are still conducted in a small area that is lower in elevation than the outlet of the pond.

The Wohler ponds would need to be periodically regraded as part of normal maintenance activities. Maintenance would also be required to remove accumulated silt and debris to maintain infiltration rates and to ensure that the ponds drain properly.

Modification of Operations at Wohler Diversion Facilities

Operations at the Wohler Diversion Facility are described in Section 3.3. Changes in the operations would center around the new facilities described above and modifications to provide better protection for listed species. Operation and maintenance of the Wohler water diversion facilities would entail:

1. Annual preparation of the infiltration ponds and diversion facilities.
2. Annual removal and installation of the screen modules.
3. Maintenance of the screen modules, including cleaning and repair after removal.
4. Automatic screen cleaning operations at a user-selectable frequency.
5. Manual adjustment of the intake slide gates as needed throughout the infiltration season.

4.2.2 TRANSMISSION SYSTEM FACILITIES

Existing diversion, distribution, and treatment facilities were presented in Section 3.3. Remaining authorized and proposed facilities are described here. Remaining authorized facilities are those that were authorized before approval of the WSTSP and are under construction or scheduled for construction in the near future. Remaining authorized facilities are needed to meet existing demand. Proposed facilities are those identified in the WSTSP that were proposed to serve future demands and expand the capacity of the existing water transmission system.

The proposed project analyzed in this BA includes both current water supply operations and potential future water supply operations that may be necessary to serve already-planned growth within the service area of SCWA's customers. In order to have some basis for evaluating the potential effects of future water supply operations, this BA assumes that SCWA will serve additional future water demands by constructing facilities and increasing diversions from the Russian River as contemplated by the WSTSP. Because of a recent Court of Appeals ruling on a lawsuit challenging the adequacy of the WSTSP EIR, SCWA must complete a supplemental environmental review of the program-level impacts of the WSTSP, and SCWA's Board of Directors must consider the impacts of that analysis when determining whether or not to re-approve the WSTSP. Thus, although it is uncertain whether the WSTSP will be carried out as described in the original EIR for the WSTSP, the inclusion of the proposed WSTSP in the present BA allows future effects to the threatened salmonid species to be evaluated based on more specific, defined assumptions than would otherwise be the case. The actual water supply facilities and diversions from the Russian River that SCWA's Board of Directors may approve in the future may differ from those contemplated by the WSTSP; nevertheless, the WSTSP provides a future project against which effects to salmonids from future water supply development may be analyzed. For this reason, the WSTSP is described and discussed in this BA, although the SCWA Board of Directors must reevaluate whether to approve the WSTSP after SCWA completes its supplemental environmental review.

4.2.3 THE WATER SUPPLY AND TRANSMISSION SYSTEM PROJECT

The three components of the WSTSP include: 1) implementation of water conservation measures that would result in the savings of approximately 6,600 AFY and expansion of the water education program; 2) increasing the amount of water diverted from the Russian River (a combination of rediversion of stored water and direct diversion of winter flow) by 26,000 AFY, thereby increasing the total amount of diversion and rediversion from 75,000 AFY to approximately 101,000 AFY; and 3) increasing the transmission system capacity by 57 mgd, thereby increasing the total capacity of the transmission system from 92 mgd to 149 mgd. Figure 4-3 illustrates conceptual locations of proposed facilities.

4.2.4 REMAINING DIVERSION FACILITIES

Facilities authorized prior to the WSTSP that remain to be completed to meet current demand include 20 mgd of standby pump and collector capacity. SCWA plans to achieve the additional 20 mgd of standby capacity in part through the operation of Collector No. 6, a Ranney-type collector well and pumphouse that is expected to commence operation in 2004. The construction of this facility underwent informal consultation with NOAA Fisheries in 1999 (NMFS 2000b). Ongoing operations and maintenance are addressed in this consultation. The Ranney collector and pumphouse will be similar to the existing Ranney collectors at SCWA's Mirabel diversion facilities.

4.2.4.1 Proposed WSTSP Diversion Facilities

Additional diversion facilities have been proposed for development in the general area of the Russian River watershed downstream of Lake Sonoma/Warm Springs Dam to meet future water demands. Diversion facilities may include additional Ranney-type collector wells, conventional wells, infiltration ponds, surface water diversion structures, water treatment facilities, pumps, connecting pipelines, and appurtenances. SCWA staff are reviewing the types and locations of diversion facilities that may be proposed. Brief descriptions are presented below and should be considered conceptual.

Ranney-Type Collector Wells (Collectors)

Collectors would be similar to those previously described for existing diversion facilities. Approximately four to six collectors would be constructed, operated, and maintained. Each collector would consist of a vertical concrete caisson with horizontal perforated intake pipes to collect naturally-filtered water from an aquifer associated with Dry Creek or the Russian River. At the top of the caisson would be a pumphouse with electric motors, pumps, and appurtenant controls for operation of the collector. Other appurtenances may include, but would not be limited to: connecting pipelines, access roads, observation wells, electrical equipment, radio telemetry equipment, water treatment (disinfection) equipment, and emergency power generators and associated fuel storage. If production capacity could be achieved via natural recharge to the aquifer, no additional diversion structures or infiltration ponds would be necessary; however, if

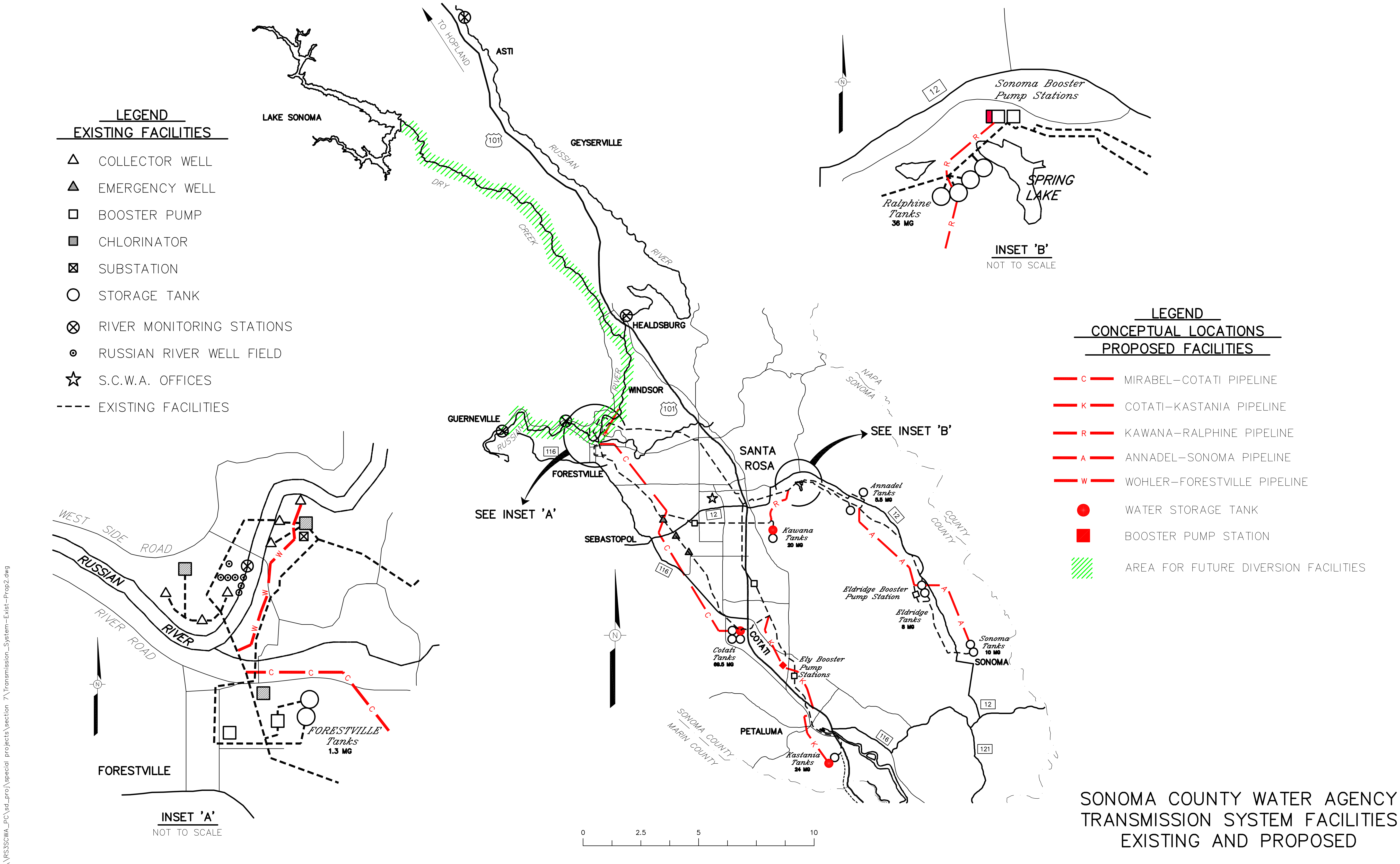

Figure 4-3 Sonoma County Water Agency Transmission System Facilities Existing and Proposed

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artificial recharge is necessary, it is likely that additional infiltration ponds or diversion structures would be required.

Conventional Wells

The SCWA system presently includes three conventional wells at Occidental Road, Sebastopol Road, and Todd Road. Approximately 19 to 29 new production wells could be constructed, operated, and maintained, with a capacity of 2 to 3 mgd for each conventional well. Well depths would be approximately 100 feet. Each well would be equipped with submersible or vertical turbine pumps. Other appurtenances may include, but not be limited to: connecting pipelines, access roads, observation wells, electrical equipment, radio telemetry equipment, water treatment (disinfection) equipment, and emergency power generators and associated fuel storage. If production capacity could be achieved via natural recharge to the aquifer, no additional diversion structures or infiltration ponds would be necessary; however, if artificial recharge is necessary, it is likely that additional infiltration ponds or diversion structures would be required.

In 1998 and 1999, SCWA drilled and developed replacement wells at the Occidental Road and Sebastopol Road well sites to restore the original water production capacity of the wells. The loss in capacity was a result of the Occidental Road well screen having collapsed, and the Sebastopol Road well producing excessive amounts of sand. The two new wells at Occidental and Sebastopol roads and the existing well at Todd Road are completed to depths of 770, 1,040, and 805 feet, respectively. The three wells are capable of producing a combined total of approximately 5 to 7 mgd. In April 1999, at the request of SCWA, CDHS amended SCWA's domestic water supply permit to allow the Todd Road well to be used as an active, rather than a standby, source. The Sebastopol Road well was permitted as an active source in 2002.

Chlorine is added to the water produced at each of the three well sites to maintain protective residual levels of chlorine within the system and prevent contamination. Calcium hypochlorite is currently used at the Sebastopol Road and Todd Road well sites, eliminating the need for chlorine gas cylinders at the sites, and this system will be installed at the Occidental Road well in the future. In addition, a treatment system has been installed at the Todd Road well, which adds a small dose of an ortho-polyphosphate compound to the well water. The treatment was installed to determine whether it would be effective at eliminating the hydrogen sulfide odor, which frequently occurs in the water produced at all three wells. Although hydrogen sulfide does not affect the potability of the water, the odor it causes is a secondary water quality concern.

Surface Water Diversion and Water Treatment Plant

Additional diversion of surface water directly from Lake Sonoma, Dry Creek, and/or the Russian River would require construction, operation, and maintenance of a water treatment plant. A water treatment plant option was included in the WSTSP.

The treatment process would likely be a conventional treatment process, Actiflow (a new, patented, filtration system that uses micro sand to enhance sedimentation), or membrane filtration. Conventional treatment processes at the plant may include, but would not be limited to, rapid mixing, coagulation, flocculation-sedimentation, filtration, and disinfection. Facilities associated with the plant may include buildings, access roads, headworks, clarifiers, filters, storage ponds and/or tanks, raw water and finished water pipelines, electrical equipment, radio telemetry equipment, disinfection equipment, and emergency power generators and associated fuel storage. A facility to divert surface water to the treatment plant would also be included. Chemicals used in the treatment and/or disinfection processes may include, but would not be limited to alum, cationic and nonionic polymers, chlorine, and caustic soda.

4.2.4.2 Proposed WSTSP Distribution Facilities

Four major pipelines were contemplated as part of the WSTSP. Pipeline construction would involve the underground installation of approximately 229,000 lf of 18- to 60-inch-diameter, mortar-lined and coated, steel pipe and appurtenances. The four proposed pipeline routes would generally parallel existing water transmission pipelines (Figure 4-3). The actual pipeline routes have not been finally identified. The following paragraphs describe the four pipelines.

> *Mirabel-Cotati Pipeline*: The Mirabel-Cotati Pipeline would extend from SCWA's facilities in the Mirabel area and generally parallel the existing Russian River-Cotati Intertie pipeline for approximately 14 miles to Cotati. The pipeline would consist of approximately 72,000 lf of 36- to 54-inch-diameter pipe.
>
> *Cotati-Kastania Pipeline*: The Cotati-Kastania Pipeline would generally parallel a portion of the existing Petaluma Aqueduct for approximately 13 miles from the Cotati tanks to the southern end of Petaluma. The pipeline would consist of approximately 66,000 lf of 24- to 48-inch-diameter pipe.
>
> *Kawana-Ralphine Pipeline*: The Kawana-Ralphine Pipeline would connect with SCWA's Kawana Springs tanks site at the end of Kawana Springs Road in southeast Santa Rosa and extend approximately 5 miles in a northeasterly direction to connect with SCWA's Ralphine Tanks and the Sonoma Booster Pump Station. The pipeline would consist of approximately 26,000 lf of 30- to 36-inch-diameter pipe.
>
> *Annadel-Sonoma Pipeline*: The Annadel-Sonoma Pipeline would generally parallel the existing Sonoma Aqueduct for approximately 13 miles from the area of Pythian Road to the Sonoma Tanks. The pipeline would consist of approximately 65,000 lf of 18- to 24-inch-diameter pipeline.

The WSTSP contemplated an additional 55.5 million gallons of storage along the transmission system, increasing the existing storage from 118.8 million gallons to 174.3 million gallons. Three to five steel water storage tanks would be constructed, operated, and maintained to provide this additional water storage. Conceptual locations are shown in Figure 4-3. One of these tanks would be a second storage tank at the Kawana Springs location. The proposed site for this tank is adjacent to Kawana Springs Tank No. 1, approximately 0.75 mile east of the intersection of Kawana Springs Road and Petaluma Hill Road. One to three additional tanks could be located near the existing tanks just west of Cotati, and another tank could be located near the existing Kastania Tank, just south of Petaluma.

Two booster pump stations were proposed as part of the WSTSP. As with the proposed pipelines, the specific locations of the pump stations are in the process of being identified. Possible locations are shown in Figure 4-3. The booster pump stations are necessary to ensure that the full delivery potential of the expanded transmission system can be achieved. The two proposed booster pumps are conceptually described below.

> *Cotati-Kastania Booster Pump Station*: This booster pump station would be located along the Cotati-Kastania Pipeline. The pump size would be between 500 and 1,500 hp, and the size of the electrical substation would be between 500 and 1,700 KW. Storage for approximately 25,000 gallons of diesel fuel would be needed.
>
> *Sonoma Booster Pump Station Modification (Station No. 2, Pumps No. 2 and 3)*: This booster pump station would be a modification of the existing Sonoma Booster Pump Station No. 2, located near Spring Lake Park in east Santa Rosa. Two pumps, each approximately 250 hp, would be installed, and modifications to the existing electrical substation would be necessary to increase power by 500 KW. Existing diesel fuel storage at the site would be increased by 15,000 gallons.

Dechlorination for Accidental Spills

The pipelines in the SCWA water transmission system include valves, which may occasionally discharge potable water to various creeks and drainage swales or ditches. Potable water may also be discharged from tank overflow lines, although this occurs far less frequently. The maximum residual chlorine concentration in these discharges is approximately 0.6 to 0.7 parts per million (ppm). The volume of such a discharge is difficult to estimate, but is likely to be as much as several thousand gallons.

Dechlorination baskets have been added to each of the 17 valves that could result in a spill of potable water if they failed. The dechlorination baskets remove the chlorine from water that is accidentally spilled. An alert system has also been installed at each of these locations so that SCWA is immediately notified if there is a spill.

4.2.4.3 Proposed Treatment Facilities

As previously discussed, additional treatment facilities may be needed as part of the expansion of the transmission system to meet future demands. However, the specific type of facilities needed will depend on the type and location of diversion facilities that are ultimately selected.

4.3 FLOW AND ESTUARY MANAGEMENT

Management of instream flow in the Russian River system consists of two primary activities: winter flood control operations and summer water supply releases. Winter flood control operations are described in Section 4.1. Summer releases are presently determined by the D1610 instream flow requirements and water supply demands.

Under D1610, flows in the Russian River and Dry Creek must be augmented with releases from storage during the summer months. *Interim Report 3* reported that the augmented flows resulted in velocities exceeding the velocities for optimal rearing habitat (ENTRIX, Inc. 2002b). The intent of the proposed changes in instream flow management is to use the reservoirs and project facilities conjunctively to improve conditions for listed salmonids. Water releases from Coyote Valley Dam will be coordinated with water releases from Warm Springs Dam with the goals of: (1) meeting water supply needs; (2) improving rearing conditions for listed salmonids in the mainstem Russian River and in Dry Creek; and (3) reducing inflow into the Estuary during the dry season (June and September or October), allowing the Estuary to be operated as a closed system.

4.3.1 WATER DEMAND AND SUPPLY

SCWA would continue to divert, store, release, and redivert water within the Russian River basin under the terms of SCWA's appropriative water rights permits to meet present and future water demand as described in Section 3.3. SCWA is currently authorized to divert and redivert a total of up to 75,000 AFY from the Russian River, at a maximum rate of 180 cfs. The WSTSP (see Section 3.3) would provide a safe, economical, and reliable water supply to meet future needs in the SCWA service area. It would increase the transmission system capacity by 57 mgd, thereby increasing the total capacity of the transmission system from 92 mgd to 149 mgd. It would increase authorized diversions to 101,000 AFY, at a maximum rate of 230 cfs.

4.3.2 FLOW PROPOSAL

Under current D1610 operations, summer flow levels in Dry Creek and the Upper Russian River result in velocities that are too high for rearing salmonids (see Section 3.3 and ENTRIX, Inc. 2002b). Additionally, the cold water pool in Lake Mendocino is depleted prior to the end of the summer rearing period, which could result in stressful temperatures in the upper and middle Russian River for juvenile steelhead in the late summer and for Chinook migrating upstream. High summer flow into the Estuary creates the need for artificial breaching the sandbar at the mouth of the Russian River in the summer period. The proposed flow regime addresses these concerns. Specific objectives of the proposed flow modifications are to:

- Reduce velocities in Dry Creek and the upper Russian River in summer.
- Conserve the cold water pool in Lake Mendocino through the late summer.

- Provide for the exercise of existing water rights in the Russian River and Dry Creek.
- Enable SCWA to meet future transmission system demands arising from approved developments in SCWA's water contractors' service areas.
- Allow the sandbar at the mouth of the Russian River to be closed in the summer.

This section describes a Flow Proposal under consideration for implementation. An implementation plan and proposed permit terms are included in Appendix B for the proposed flow regime. Evaluations of the Flow Proposal and potential effects associated with its implementation are ongoing.

Winter flows in the Russian River and Dry Creek are the result of natural runoff from unregulated streams and flood control operations at Coyote Valley Dam and Warm Springs Dam. This Flow Proposal would not substantially alter winter flow management. Summer flows would be lower in the Russian River and Dry Creek, as would summer inflow to the Estuary. The proposed Estuary management is discussed in Section 4.3.3. The following discussion of the Flow Proposal focuses on summer (June to October) conditions. Flows are summarized for two cases: *all* water supply conditions, which combines the *normal*, *dry*, *dry spring*, and *critically dry* as defined by D1610; and *dry* water supply conditions, which describes the flows that occur during *dry* water supply conditions as defined by D1610. (Water supply conditions are defined in Section 3.4.1.)

4.3.2.1 Russian River between East Fork and Dry Creek Confluence

Flow releases to the Russian River between the East Fork and Dry Creek (upper and middle Russian River) would be managed to: provide suitable conditions in the Russian River for rearing salmonids during the summer months, to allow the Estuary to remain closed, to satisfy mainstem water rights, and to meet SCWA's water supply objectives at Wohler and Mirabel. This would be accomplished by coordinating the flow releases from Warm Springs Dam and Coyote Valley Dam. Minimum flow requirements at Healdsburg would range from 50 to 150 cfs during *normal*, *dry*, and *dry spring* water supply conditions for the portion of the river between the Forks and Dry Creek, with a minimum flow in the East Fork of 25 cfs at all times (Table 4-2). An exception to the *normal* flow requirements would occur if, anytime between November 1 through December 31, storage in Lake Mendocino fell below 30,000 acre-feet, then the required minimum flow rate would be reduced from 150 cfs to 75 cfs. During *dry* and *critically dry* water supply conditions, minimum required flows in the upper and middle Russian River would be reduced to 25 cfs. Summer flows in the upper and middle Russian River would usually exceed the minimum required flows in order to meet all water supply needs.

Table 4-2 Proposed Minimum Streamflow Requirements (cfs) for the Upper and Middle Russian River

	Month											
Water Supply Condition	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Normal	150	150	150	100	100	50	50	50	50	50	150/75[1]	150/75[1]
Dry	75	75	75	75	75	50	50	50	50	50	75	75
Critically Dry	25	25	25	25	25	25	25	25	25	25	25	25
Dry Spring	150	150	150	100	100	50	50	50	50	50	75	75
East Fork	25	25	25	25	25	25	25	25	25	25	25	25

[1]75 cfs when storage in Lake Mendocino is less than 30,000 AF.

4.3.2.2 Russian River below Mirabel Inflatable Dam

Flows in the Russian River below the Mirabel Dam would be managed to avoid the need to breach the sandbar at the mouth of the Russian River during the summer. Minimum flows at the Hacienda gage would be the greater of 35 cfs or the “natural flow.”

The “natural flow” of the lower Russian River is intended to mimic the flow in the lower river under predevelopment conditions. The implementation plan in Appendix B describes the process for determining the “natural flow.” This flow scenario uses flows in Austin Creek or Maacama Creek to predict what the natural flow would be in the Russian River. The natural flow of the Russian River at Hacienda Bridge is defined as 11.77 times the 4-day running average of the gaged flow of Austin Creek (USGS Gage No. 11467200). During periods in which that gage is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the 4-day running average of the gaged flow in Maacama Creek at the USGS gaging station near Kellogg, California. Generally, natural flow would be the minimum flow during the summer months, but the required minimum flow would never be less than 35 cfs. In order to ensure that this minimum flow is met operationally, the minimum flow target would be 50 cfs. Releases from storage would be made to maintain the required minimum flow until flows naturally increase above a specified “transition flow” after which no additional water would be released from storage to maintain the “natural flow.” The transition flow describes when natural runoff becomes the dominant factor determining flows and project operations are less important (Table 4-3). When the “natural flow” in the lower Russian River exceeds the transition flow rate, the required minimum instream flow would be the transition flow.

Table 4-3 Proposed Lower Russian River Transition Flow Rates (cfs)

	Month											
Water Supply Condition	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Normal	125	125	125	150	150	125	125	125	125	125	125	125
Dry	125	125	125	150	150	125	125	125	125	125	125	125
Critically Dry	35	35	35	35	35	35	35	35	35	125	125	125

When the Estuary closes (typically between July and October), the minimum flows at Hacienda Bridge would be the lesser of the natural flow or the Optimal Estuary Inflow. The Optimal Estuary Inflow rate is the rate that would maintain the water surface elevation (WSE) at the Jenner gage at 7.0 feet. SCWA's preliminary analyses indicate that the inflow to the Estuary that will maintain a stable water surface elevation at this level is approximately 90 cfs at Hacienda. This level will avoid the local flooding that requires the sandbar to be breached periodically under current operations, and will allow the Estuary to remain closed. A closed system is expected to improve rearing habitat for salmonids in the lower part of the river.

4.3.2.3 Dry Creek

The minimum flow rates required under D1610 in Dry Creek would be modified so that the optimum range of flows for rearing coho salmon, steelhead, and Chinook salmon would normally be provided (Table 4-4). The optimum range of flows for rearing habitat is 30 to 70 cfs for steelhead fry and 30 to 90 cfs for coho salmon fry (Appendix C).

Table 4-4 Proposed Minimum Streamflow Requirements (cfs) for Dry Creek

	Month											
Water Supply Condition	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Normal	90	90	90	50	50	25	25	25	25	25	90	90
Dry	75	75	75	50	50	25	25	25	25	25	75	75
Critically Dry	75	75	75	50	50	25	25	25	25	25	75	75

Under the Flow Proposal, the flow requirements for Dry Creek would be modified so that under *normal* water supply conditions, flows during May through October would be managed at the mouth to provide suitable rearing flows. The Flow Proposal strives to provide the operational flexibility to meet short-term increases in water demand at Mirabel, and to manage the inflow to the Estuary. At buildout, summer releases from Lake Sonoma in excess of 90 cfs would be expected only during *critically dry* water supply conditions (approximately 2 percent of the summer periods). Releases from Lake Sonoma of this magnitude would be required to avoid dewatering Lake Mendocino. During *critically dry* water supply conditions, releases from Lake Mendocino would be reduced, and releases from Lake Sonoma would be increased to meet water demands at Mirabel. Minimum flow requirements in Dry Creek would range from 25 cfs in the summer months to 90 cfs in November and December.

4.3.2.4 Additional Measures

To maintain suitable rearing habitat for young salmonids as water demand increases in the future, SCWA would develop additional measures to meet the additional demand. These measures would minimize the need to release additional water into the Upper Russian River or Dry Creek during summer. The primary additional measures being considered are:

- An aquifer storage and recovery (ASR) program;
- A pipeline from Warm Springs Dam to the mouth of Dry Creek, the Wohler diversion facility, or a treatment plant; and
- Other storage facilities to be developed by SCWA.

SCWA may develop and implement a combination of these options, or others, in a phased manner as demand increases. While these measures are unnecessary under the existing demands, they will likely be necessary in the future. Future studies would need to be conducted to evaluate the feasibility of these concepts. The ASR and pipeline options are described on a conceptual basis below.

Aquifer Storage and Recovery

ASR is a method of water resource management utilized throughout the U.S. and the world that uses surface water supplies conjunctively with groundwater resources. For example, ASR is a water resource management strategy proposed by the CALFED Bay-Delta Authority. Conceptually, an ASR strategy would involve pumping water from SCWA's diversion facilities at the Russian River through the transmission system to groundwater recharge facilities in areas such as the Sonoma Valley, Santa Rosa Plain, or Petaluma Valley. This program would coordinate the timing of diversions from the Russian River to more closely match natural flow conditions. For example, relative to current practices, diversion of Russian River water would be increased when flows are naturally high in the winter and spring and reduced during the summer months when river flows are naturally low. Water diverted during the high flow (winter/spring) season would be stored in aquifers that are not contiguous with the Russian River. Water would be extracted from the storage in these off-river aquifers during the peak-demand (summer/early fall) season, thereby reducing the amount of water that would be diverted from the Russian River during periods of peak demand. This method of operation would allow lower flows to be maintained in Dry Creek and the upper Russian River during the summer.

Water would be diverted from the Russian River for aquifer storage during the wet season. Diversions from the Russian River would continue up to the allowable annual limits in SCWA's water rights permits. However, the timing of diversions would be modified as described above relative to current operations.

Additional diversion facilities may include Ranney-type collector wells, conventional wells, infiltration ponds, diversion structures, water treatment facilities, pumps, connecting pipelines, and related appurtenances.

ASR would improve operational flexibility and reliability as it would increase the diversity of supply sources available to meet demand and distribute these sources of water throughout Sonoma County. These supplies could be used to meet peak demands. The increased diversity of supply sources would also provide greater regional water supply reliability in the event of some catastrophic event that might impair the ability to divert and transport water from the Russian River. ASR would also reduce the number of diversion facilities along the Russian River that would be required to meet future water demands. The ASR concept would be studied further to determine its feasibility.

Pipeline

Another measure of reducing flows in the Russian River and Dry Creek is to construct a pipeline from Warm Springs Dam. This pipeline could terminate either at the mouth of Dry Creek, the Mirabel facilities, or at a treatment plant at a site to be determined. A new pipeline would likely be installed in the dam's wet well or outlet structure of Warm Springs Dam, or may require construction of a new outlet structure. To construct the pipeline, the Agency would need to obtain rights of way along Dry Creek and the Russian River. Releases from Warm Springs Dam to Dry Creek would remain in the range described for optimal salmonid rearing conditions. Any additional flow releases needed to meet water supply needs would be conveyed through the pipeline.

4.3.2.5 Modeling the Flow Proposal

Habitat conditions for listed salmonids under the Flow Proposal were evaluated using the RRSM and RRWQM models developed by SCWA. Model simulations were used to predict flow rates, temperature and DO levels in the Russian River and Dry Creek under the proposed management scenario. Simulations were run using the same hydrologic and meteorological constraints as those use to model flows under D1610. These constraints included known precipitation patterns, historical and projected future demand patterns, variations in climatic conditions, and local runoff levels in different areas of the watershed (Flugum 1996).

The models simulated a 90-year period on the Russian River, from 1910 to 2000. During model runs, each month is assigned to a water supply category (*normal*, *dry*, or *critically dry)* based on storage levels in Lakes Pillsbury and Mendocino (see Section 3.4.3). Simulations were conducted using two different water use scenarios, current and buildout demand levels. Current demand levels refer to the existing use of Russian River water required to supply urban and agricultural needs. Buildout demand levels reflects the maximum water demand that the WSTSP is designed to meet (Section 3.3.2).

Model output provides daily flow, temperature, and DO at specific locations (model nodes) along the Russian River and Dry Creek over the 90-year simulation period (Table 4-5). Habitat conditions for listed salmonids are assessed based on the distribution of these output values and their relative scores (as defined in Appendix C) for salmon species at different stages in their lifecycle (see Section 5.3 for details).

The Flow Proposal is expected to improve summer rearing conditions (June-October) for salmonids in the Russian River and Dry Creek relative to D1610. The Flow Proposal focused on this period, because this is the time of year when the project has the greatest effect on riverine conditions. This is also the time when conditions are most limiting for salmonids, because of warm water temperatures and reduced living space in the tributaries (the primary rearing habitat) due to low flows, and higher than optimal

Table 4-5 Median Flows (cfs) in the Russian River and Dry Creek for the Flow Proposal

Current Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	744	928	516	604	290	187	163	160	143	127	174	387
Hopland	859	1088	625	684	312	184	152	150	137	124	177	424
Cloverdale	1084	1400	854	833	361	183	140	137	130	122	191	507
Healdsburg	1663	2181	1420	1193	501	181	119	128	126	141	227	664
Below Dry Creek	2086	3003	1985	1448	580	236	174	179	179	200	329	805
Hacienda	2692	3912	2677	1795	672	188	78	68	78	119	313	930
Warm Springs Dam	91	350	275	139	53	63	74	63	57	54	91	91
Lower Dry Creek	235	562	393	196	64	57	61	56	55	55	96	122

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	169	594	268	266	224	205	185	152	145	95	105	170
Hopland	189	665	349	286	229	194	170	145	138	94	109	184
Cloverdale	271	807	533	331	248	181	147	134	129	93	130	223
Healdsburg	466	1210	875	442	286	149	103	127	123	93	130	276
Below Dry Creek	594	1416	1077	517	338	208	169	178	175	148	210	374
Hacienda	767	1930	1511	596	327	123	52	65	71	57	169	408
Warm Springs Dam	76	76	76	51	51	71	83	63	58	56	78	76
Lower Dry Creek	110	150	148	71	58	60	69	57	55	56	80	96

Buildout Demand Level

All Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	726	913	512	599	298	191	205	160	146	137	177	371
Hopland	838	1081	617	677	315	185	192	149	140	135	180	407
Cloverdale	1075	1384	851	825	357	180	176	133	131	134	187	481
Healdsburg	1591	2127	1383	1172	478	178	151	120	124	134	190	602
Below Dry Creek	1992	2925	1954	1428	562	239	213	183	192	188	290	742
Hacienda	2577	3806	2577	1739	582	170	79	54	49	65	230	828
Warm Springs Dam	91	302	265	140	60	73	88	83	78	55	91	91
Lower Dry Creek	230	513	382	197	73	60	67	70	70	55	96	122

Dry Water Supply Conditions

Stations	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Ukiah	174	583	283	230	245	222	236	155	154	117	120	160
Hopland	190	645	365	257	237	207	214	145	145	116	124	177
Cloverdale	270	780	541	312	254	185	186	131	133	115	129	204
Healdsburg	419	1170	847	379	289	147	138	119	124	112	130	215
Below Dry Creek	553	1365	1048	459	352	219	210	182	192	177	209	312
Hacienda	681	1779	1443	492	268	110	53	50	45	49	125	302
Warm Springs Dam	76	76	76	51	56	83	101	83	82	65	78	76
Lower Dry Creek	110	150	150	72	63	66	78	70	73	65	80	97

velocities in the Russian River and Dry Creek. The predicted median flows provided by Flow Proposal under current and buildout conditions are described in the following two sections below.

Current Demand Levels

Under *all* water supply conditions, the Flow Proposal would provide median flows ranging from approximately 119 to 187 cfs in the middle and upper Russian River between June and October (Table 4-5). These flows generally provide highly suitable rearing conditions for young steelhead. Juvenile Chinook salmon are not affected by managed flows at this time of year as they have usually migrated out to sea by July. Coho salmon are also not affected by these flows, as they generally rear in the tributaries. Flows tend to be slightly lower during the late summer and fall months in the lower portion of the mainstem (Hacienda Bridge); however, this has little impact on steelhead since they mostly rear in the middle and upper Russian River.

Under *dry* water supply conditions, the Flow Proposal would provide median flows ranging from 103 to 205 cfs in the middle and upper Russian River between June and October. Flows above Healdsburg are predicted to be higher in the summer (June and July) compared to *all* water supply conditions, and slightly lower in October. Flow rates decrease moving downstream from Healdsburg, ranging from about 57 to 123 cfs at the Hacienda.

During the rest of the year, flow rates increase from November to February and then decrease through the spring (May 31). Flows during this time of year are largely due to natural runoff and seasonal rains rather than dam operations on the Russian River. In the upper mainstem (Ukiah) median monthly flows range from about 170 cfs (November) to 925 cfs (February), under *all* water supply conditions, and from 95 to 595 cfs under *dry* water supply conditions. In general, monthly flow rates increase as you move downstream from Ukiah, with the highest flows occurring at Hacienda Bridge. These flow conditions coincide with upstream migration, spawning, and incubation life stages of all three listed species.

In Dry Creek, median flows for June through October are predicted to range from about 55 to 75 cfs, for *all* and *dry* water supply conditions. Flows during this time period are similar throughout the entire reach. The low flows provided by the Flow Proposal in the summer and fall are expected to improve rearing conditions for juvenile coho salmon (should populations increase in this reach) and steelhead within Dry Creek. Median flow conditions are predicted to be fairly similar between current and buildout demand levels. Under *critically dry* water supply conditions, which occur about 2 percent of the time during the summer months, flows would range from 94 to 148 cfs from June through October. While higher than optimal, these flows would still be substantially lower than those occurring under D1610 under even *dry* water supply conditions (which occur about 15 percent of the time).

During November through May, flows in Dry Creek under *all* water supply conditions would range from about 90 to 300 cfs. The lowest flows would occur in November through January, while February would have the highest flows. In *dry* water supply conditions, flows would be much lower and more constant at about 75 cfs from January through March and 50 cfs in April and May.

Buildout Demand Levels

To maintain the improved conditions that this Flow Proposal would create for salmonids as water demands increase in the future, SCWA will develop and implement one or more additional measures to allow flows to remain near the levels described above. The primary measures being considered are: an aquifer storage and recovery (ASR) program; a pipeline from Warm Springs Dam to the mouth of Dry Creek, the Wohler diversion facility, or a treatment plant; and additional storage facilities (see following section).

Under this Flow Proposal, flows in the middle and upper Russian River are anticipated to remain stable over time as water supply demand increases. Median flows in Dry Creek are anticipated to increase slightly under the future demand scenario (relative to existing demand), but would remain within the range of suitable flows for salmonid rearing. Flows at Hacienda are expected to be similar to those under existing demands in the summer months. It is anticipated that the Estuary could be managed as a closed system from July through October under both current and future water supply demands.

Flows under buildout demand levels were modeled assuming that additional measures would be implemented to maintain suitable rearing flows under future water demands. During June through October, median flows in the middle and upper Russian River (Healdsburg to Ukiah) would range from approximately 120 to 205 cfs under *all* water supply conditions and from 112 to 236 cfs under *dry* water supply conditions. Flows in these ranges would provide good to optimal rearing conditions for juvenile steelhead.

Median flows in the lower Russian River (Hacienda Bridge) are reduced relative to those in the upper mainstem. In general, flows are the same under *all* and *dry* water supply conditions, ranging from about 45 to 110 cfs, except in June, when median flows are 60 cfs higher under *all* water supply conditions (160 cfs). Steelhead do not usually rear in this region of the Russian River, however, median flow conditions are expected to remain highly suitable for juveniles. During the rest of the year, flow rates increase from November to February and are similar to current demand levels. Flows are higher under *all* water supply conditions ranging form 177 cfs (Ukiah in November) to 3806 cfs (Hacienda Bridge in February), compared to a range of 120 to 1779 cfs under *dry* water supply conditions.

Under Buildout demand in Dry Creek, median flows between June and October are similar throughout the upper and lower reaches. Under *all* water supply conditions, flows are predicted to range from 55 and 83 cfs, and should provide excellent to optimal rearing conditions for coho salmon and steelhead.

Under *dry* water supply conditions, median flows are about 10 to 20 cfs higher, ranging form 63 to 101 cfs during the summer months. These flows are still expected to provide good to excellent rearing conditions for juvenile salmonids, except in July, when flows may be somewhat stressful. At buildout demand levels under *critically dry* water supply conditions, which occur about 2 percent of the time during the summer months, flows would range from 139 to 200 cfs from June through October. These flows would be lower than under *dry* water supply conditions for D1610. *Dry* water supply conditions occur about seven times more frequently than *critically dry* water supply conditions.

During November through May, flows in Dry Creek would be similar to those under existing demand levels for both *all* and *dry* water supply conditions.

4.3.3 Estuary Management

The objective of the Estuary management proposal is to improve habitat for listed salmonid species while preventing flooding of local properties. To improve summer rearing habitat in the Estuary, the proposed project would eliminate artificial breaching of the sandbar during the summer months. Artificial breaching may be required in the spring or fall, and in some dry winters, to manage storm flow inflows to the Estuary to prevent flooding of local property.

Estuaries and lagoons in the Central California Coast and Northern California Steelhead ESUs provide important summer rearing habitat for steelhead and Chinook salmon (Anderson 1995, 1998, 1999; Cannata 1998; Larson 1987; Smith 1990). Summertime breaching of sandbars has been found to severely alter steelhead habitat conditions in lagoons (Smith 1990), and summertime breaching can negatively affect salmonids (Anderson 1995, Smith 1990). Infrequent artificial breaching, especially during low-flow summer months, impairs water quality because salinity stratification repeatedly results in periods of higher water temperatures and low DO levels (Smith 1990; MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Fluctuations in temperature, DO, and salinity affect salmonid habitat, primary production, and the abundance of aquatic invertebrates upon which young salmonids feed (Smith 1990). Smith (1990) found that when a sandbar is left closed over the summer months, good water quality develops when the system is converted to fresh water, and stable habitat conditions form. Habitat conditions for salmonids in the Estuary would be improved by eliminating artificial breaching in the summer.

Under the proposed action, there would be two management scenarios, one for Low-flow Estuary Management and one for Storm-flow Estuary Management. The Estuary would be managed with the goal of maintaining a closed system (lagoon) with freshwater habitat during the low-flow (summer) season. This action is expected to improve summer rearing habitat by allowing the lagoon to freshen and by stabilizing salinity and dissolved oxygen conditions, which would also increase and stabilize the invertebrate food base for salmonids. The frequency of breaching and the amount of freshwater inflow are two major factors that influence water quality in a lagoon or estuary system. Under the Flow Proposal, flow to the Estuary would be low enough to avoid artificial breaching in the summer, but high to freshen the lagoon after the sandbar first closes. Under Storm-flow Estuary Management, artificial breaching would be conducted to manage the Estuary as an open system during the wet season to minimize flooding of local property.

Under D1610, the Estuary cannot be managed as a closed system during *normal* water supply conditions because required minimum flows at Hacienda provide inflow rates to the Estuary that are too high to avoid flooding if the sandbar is not breached. Therefore, the proposed Estuary management action could only be implemented in concert with reduced flows such as those in the Flow Proposal. Implementation of the Flow Proposal allows dry season inflow to the Estuary to be substantially lower than permitted under D1610.

4.3.3.1 Low-Flow Estuary Management

Once the sandbar forms across the river mouth at the end of the wet season, flow in the Russian River to the Estuary would be managed to maintain a WSE of approximately 7.0 feet or less as recorded on the Jenner gage, but may vary from 6.0 to 8.0 ft during the low flow period when the sandbar first closes, WSE may initially be approximately 4.5 ft). This would eliminate the need to artificially breach the sandbar that forms across the river mouth during the dry season. Under this scenario, the system would be managed as a lagoon (sandbar closed). Based on an analysis of the relationship between flow at the Hacienda gage and stage change at Jenner, a preliminary estimate of the flow at which a stable WSE of 7.0 feet would be maintained (when inflow and outflow through the sandbar are equal) is approximately 90 cfs (estimated range of 50 to 100 cfs) (C. Murray, SCWA, pers. comm. 2003).

Under the Flow Proposal, required minimum flow rates in the Russian River (at Hacienda Bridge) during the spring-summer transition would track the natural flow, calculated using flows in Austin Creek or Maacama Creek, until the natural flow rate declines below the floor value of 35 cfs, where the minimum flow rate remains until the natural flow rate increases above 35 cfs, then the natural flow would again be the required minimum flow (See Appendix B). The Estuary WSE that would result from these flow rates would be approximately 7.0 feet when the lagoon first closes, but would likely vary from 8.0 feet in the early summer to approximately 6.0 feet, generally later in the summer.

4.3.3.2 Storm-Flow Estuary Management

Artificial breaching of the sandbar across the mouth of the Russian River would still be required to manage storm flows and prevent flooding to private property and roads. Inundation of property begins at a WSE of approximately 10 feet, but the sandbar closing the mouth can reach elevations above 15 feet (RREITF 1994). Because the sandbar would generally be artificially breached when a storm approaches, it is unlikely that the WSE in the lagoon would exceed 8 feet. Repeated breaching would be implemented if inflow is insufficient to maintain an open mouth, but high enough to cause flooding. Repeated breaching may be necessary in dry winters.

Two basic categories of breaching events, early season and late season, are based on their potential to affect water quality in the Estuary or in a lagoon environment.

Early Season Breach Events

Early season artificial breach events are defined as those that would occur at the onset of the rainy season in the fall. If storms did not occur earlier, the sandbar would likely be opened in mid-October when USACE begins to release water from Lakes Mendocino and Sonoma to bring these reservoirs down to flood control levels for the winter. Artificial breaching would be conducted as close as is practical to the time that a natural breach would occur, but would be implemented before WSE exceeds a target of 8 feet, although actual WSE may be slightly higher than this target. The timing of natural sandbar breaching is variable and depends on local weather patterns, ocean conditions, runoff from the Russian River basin, and inflow to the lagoon.

Artificial breaching would be undertaken when an imminent threat of flooding exists, or when the WSE of the lagoon, as recorded at the Jenner gage, is rising at a rate that indicates it will reach the 10-foot flooding elevation within 48 hours. The timing of the breaching activity would be conducted earlier if work conditions pose safety risks to crews. The objective of this protocol is to time the artificial breaching as close as possible to the time that natural breaching would occur without undue risk to personnel or equipment.

Late Season Breach Events

Late season breach events are defined as those that occur near or after the end of the rainy season. Because late season breachings during low-flow periods can be an important factor in summer water quality conditions, they will be minimized to the extent practical. Late season breaches will only be conducted if runoff from a rainfall event is likely to result at a WSE greater than 8.0 feet. It is expected that, with an initial target WSE of approximately 7.0 feet at the Jenner gage, there would be sufficient inflow for rapid conversion to freshwater conditions.

Breaching Protocols

Heavy equipment for breaching would be restricted to the beach area, and staging would take place away from water. The equipment would be brought to the breaching area over the shortest route possible. The sandbar would be breached north of the jetty, at least 150 feet from the oceanside point of the jetty.

Following the decision to breach, 2 full days are required to mobilize equipment and issue notifications. Sandbar breaching can take from 1 to 10 hours. Initial breaching of the sandbar would normally be completed using a bulldozer or similar equipment. The shortest distance between the lagoon and the ocean would be selected as the breaching location so that a minimum amount of sand would be moved. A plot channel would be dug between the ocean and the lagoon, leaving a narrow sand berm between the breaching channel and lagoon. This berm would extend the width of the excavated channel, and be wide enough to retain water within the lagoon. A bulldozer would shape a channel by pushing sand to the north and south of the breach area until the bottom of the channel is level with the lagoon WSE. A bulldozer would then remove the narrow sand berm with a final pass.

The erosive force of the water that runs from the lagoon through the pilot channel will widen and deepen the channel, creating a large outflow channel across the breach within a few hours. By the time water has drained from the Estuary, the channel may be approximately 100 feet wide. Because inflow can exceed initial breaching outflow, the lagoon may continue to rise after initial breaching, and outflow and inflow may balance after a number of hours.

The excavated sand would be placed on the beach. The surf would rework the sand during the subsequent few days. In the winter, steep, high-frequency waves tend to move sand from the beach to an offshore bar. In the summer, the waves are smaller and farther apart, and move the sand from the sandbar back to the beach.

4.4 CHANNEL MAINTENANCE

SCWA would continue to conduct channel maintenance activities in the Russian River and its tributaries to reduce the potential for flooding and erosion. SCWA's actions include:

- Flood control and bank erosion control in the Mark West Creek watershed.
- Flood control in the Central Sonoma Watershed Project.
- Activities related to Coyote Valley Dam and Warm Springs Dam.
- Streambank erosion control in the Russian River.
- Emergency actions in natural channels.

Some of the proposed activities are sediment maintenance, channel debris clearing, vegetation maintenance, bank stabilization, Additionally, top-of-bank landscape and structure maintenance, and storm-drain outfall maintenance are performed. An overview of baseline conditions and practices in these categories is provided in Section 3.6. The following proposed modifications to channel maintenance activities are described in this section.

- Channel maintenance within the Central Sonoma Watershed Project and Mark West Creek watershed.
- Russian River
  - Channel maintenance related to the construction and operation of Coyote Valley Dam.
  - Channel maintenance related to USACE-identified and USACE-constructed flood and erosion control sites (federal sites).
  - Channel maintenance related to Public Law 84-99 sites (nonfederal sites).

- Debris removal as necessary to protect life and property.

- Dry Creek channel maintenance related to the construction and operation of Warm Springs Dam (federal sites and one Public Law 84-99 nonfederal levee).

- NPDES stormwater discharge permit activities.

Channel maintenance would be conducted as a cooperative effort between SCWA operation and maintenance staff and biologists to achieve both flood control and aquatic and riparian habitat objectives. Channel maintenance would be conducted in accordance with SWRCB WDR 81-73. SCWA would comply with the BMPs described in the San Francisco Bay Area Stormwater Management Agencies Association's *Flood Control Facility Maintenance Best Management Practices – A Manual for Minimizing Environmental Impacts from Stream and Channel Maintenance Activities*.

MCRRFCD would continue to conduct channel maintenance activities related to the CVDP in Mendocino County. This includes maintenance of federal sites and inspections of Public Law 84-99 sites. MCRRFCD would also conduct activities related to streambank stabilization in the mainstem Russian River.

SCWA would also perform channel maintenance activities on channels in the Russian River watershed that have undergone restoration activities. For example, SCWA has entered into an agreement with the City of Santa Rosa regarding maintenance of portions of Santa Rosa Creek upon completion of the City of Santa Rosa's Prince Memorial Greenway project.

SCWA would perform channel maintenance activities for certain natural channels, constructed flood control channels, and those flood control channels that have been modified to provide increased habitat value for fish and wildlife species.

The following sections describe channel maintenance activities for sediment maintenance, channel debris clearing, vegetation maintenance, and bank stabilization. Channel maintenance activities in constructed flood control channels differ from those in natural waterways, and are discussed separately. In addition, channel maintenance activities in Dry Creek and the Russian River are discussed separately from other activities in natural waterways.

Infiltration capacity at the Wohler and Mirabel diversion facilities would be augmented by periodically recontouring gravel bars in the Russian River upstream of the inflatable dam and also downstream of the inflatable dam near the Mirabel/Wohler infiltration ponds.

4.4.1 SEDIMENT REMOVAL AND CHANNEL DEBRIS CLEARING

Sediment buildup in flood control channels can reduce the capacity of the channels and reduce the level of flood protection. Sediment removal and vegetation removal activities are necessary to maintain channel capacity and control streambank erosion. SCWA would continue to conduct channel maintenance activities on more than 300 miles of streams within Sonoma County, most of which are located in the Russian River watershed, including both constructed flood control channels and natural waterways (Tables 3-12 and 3-14, respectively). Sediment removal would be done as-needed in constructed flood control channels. Occasionally, emergency sediment and debris removal would be conducted on natural waterways in response to an event such as a large storm, as defined under USACE nationwide permits.

4.4.1.1 Constructed Flood Control Channels

Sediment and debris removal and vegetation maintenance would be conducted to maintain flood capacity of constructed flood control channels. Excessive sediments tend to be deposited at locations where the channel gradient significantly decreases, such as along Hinebaugh and Copeland creeks, and as the channel traverses from the steep gradient headwaters on Sonoma Mountain to the low-gradient valley plain in Cotati and Rohnert Park. Sediment removal would be conducted on an as-needed basis.

Streams would be scheduled for sediment removal when field inspections indicate that the invert elevation of outfall structures is generally less than 12 inches above the streambed elevation. Sediment removal would be performed during summer or fall months until October 31. Only segments of the channel reach that inspections determine have become hydraulically impaired would have sediment removed. Sediment removal would consist of excavation of bars that have accumulated bed material and become enlarged by deposition over time.

The bars tend to create a meandering, sinuous pattern along the low-flow channel bottom. The bars effectively create a narrower channel bottom so that the low-flow channel has greater depth for a given flow than without the bar deposits. This improves fish passage for both upstream adult migration and outmigration by juvenile steelhead.

SCWA would evaluate the feasibility of actions that maintain a low-flow channel as part of the sediment removal work, and implement those actions in channels where it has the potential to improve availability of quality habitat without compromising flood control capacity. Channels that require more frequent or aggressive maintenance and that provide access to upstream spawning or rearing habitat will reap maximum biological benefit.

The goal is to maintain some low-flow channel sinuosity that provides better depths for migration following sediment maintenance. One option is to lower the height of the bar deposits by excavation, but leave a portion of the deposit in place above the channel design invert, and excavate a low-flow channel. This could result in the need for more frequent sediment maintenance activities to maintain channel capacity, but would improve water depths for fish passage.

4.4.1.2 Natural Waterways

SCWA would not perform routine sediment removal activities in natural waterways. SCWA has hydraulic maintenance easements that are permissive and SCWA would continue to access various natural creeks to remove debris or vegetation to restore hydraulic capacity (Table 3-14).

Two- to four-person crews would clear brush by hand with chainsaws and loppers. In heavy brush, a chipper would be used to break up the slash so that it can be disposed of, rather than leaving it to decay in the stream. Larger material would be cut into shorter lengths and removed from the site. Woody material would be cut up and pulled out by a truck with a winch. Trees and limbs would be removed from the stream channel only if required for flood protection.

While planting native vegetation would not be a standard practice during channel maintenance activities, occasionally native tree planting projects by volunteer groups would be coordinated or permitted by SCWA. SCWA and CDFG have implemented riparian enhancement projects to increase canopy cover, and these are discussed in Section 4.5.

Occasionally, emergency sediment and debris removal would be conducted on natural channels, including the Russian River. This would usually occur in response to an event such as a large storm that produces situations where channel flood capacity is diminished and streambanks are threatened or damaged (discussed in Section 3.6).

SCWA has developed BMPs and other guidelines for planning and implementing sediment removal and bank stabilization work performed in natural waterways to protect listed species and to minimize the potential for significant habitat alterations. SCWA would continue to use the BMP and guidelines summarized below:

- Sediment removal and bank stabilization projects are not to exceed 1,000 feet in length for any single project.
- Projects that are within 1,000 feet of a previously armored site are not implemented.
- Construction occurs during the summer to avoid spawning and incubation periods.
- A qualified fisheries biologist consults on the project design prior to implementation to consider all feasible alternatives. Habitat and biological resources in the area are evaluated.
- Projects are developed in consultation with CDFG.
- Bio-engineering bank stabilization methods are given priority where they will provide effective erosion control.
- Where bio-engineering bank stabilization methods are not deemed to be practical, then priority is given to incorporating vegetative plantings into the hard-armoring techniques that are implemented.
- Fish habitat restoration elements (such as native material revetments) are incorporated into bank stabilization practices where they are feasible with the intention of replacing lost habitat.

If large woody debris is present in excavated sediments, then it is removed from the channel only if it threatens to de-stabilize a section of streambank.

4.4.1.3 Flood Control Reservoirs

Flood control reservoirs are designed to impound water during the rainy season to reduce the potential for flooding in downstream urbanizing areas. Brush Creek Reservoir (137-AF capacity), Piner Creek Reservoir (175-AF capacity), and Spring Creek diversion (negligible capacity) are relatively small reservoirs that dry up by the summer (B. Oller, SCWA, pers. comm. 2001). Matanzas and Spring Lake reservoirs have larger capacities (1,525 AF and 3,550 AF, respectively) and do not dry up during the summer nor do they spill downstream during the summer season. Spring Lake is located offstream and continuously holds water. The Sonoma County Park Department adds water (after October when peak water demands are reduced) to maintain a recreational lake. A small tributary spring at the Spring Lake diversion facility also feeds water to Spring Lake.

SCWA flood control reservoirs would continue to be operated as described in Section 3.6.1. Maintenance activities include desiltation and removal of noxious pondweeds. Desiltation, debris removal, and vegetation removal would also be performed at the inlets and outfalls to the reservoirs. Sediments would be excavated to restore the flood control capacity.

Sediment would be removed as needed in the flood control reservoirs maintained by SCWA (i.e., Spring Lake, Brush Creek, Paulin Creek, Matanzas Creek, and Spring Creek diversion facility). Sediment excavation would be performed either when the reservoir is dry, or when there is no flow out from the reservoir. Matanzas, Spring Lake, and Piner reservoirs would be drained before sediment removal activities. The frequency of this maintenance would vary, depending on the reservoir and the level of sediment that has accumulated, but could be from every 3 to 10 years. Vegetation removal at the outfall of the reservoirs could occur annually, if needed.

At Spring Lake, approximately 1,000 cubic yards of sediment (mostly sand and silt rather than coarse sediments) would be removed from the inlet channel about once every 5 years, especially after a large flood event. The inlet channel that drains into the lake captures sediment before it enters the lake so that frequent desiltation of Spring Lake is not necessary. A weir keeps most of the coarse sediments out of the basin. Spring Lake was drained and bulldozed in 1985 to remove hydrilla (an aquatic noxious weed), and this may be done in the future if needed.

Spring Lake differs from the other reservoirs in that it holds significantly more water through the summer. The lake covers a large area, but has an average depth of only about 15 feet. There are two outlets to Santa Rosa Creek, a 6-foot wide by 8-foot deep outlet structure that carries the primary flow during flood events, and a principal spillway that carries any excess water. Before removal of hydrilla and any needed desiltation, the lake would be dewatered by pumping to Santa Rosa Creek. Screening during the dewatering process prevents the release of predators from the lake. Fish rescues would be conducted and salmonids released to the stream. When Spring Lake is drained for maintenance work, it would be drained as early as possible in the spring, typically in April, before lake waters become very warm, to avoid increasing water temperatures in Santa Rosa Creek (the recipient of water from Spring Lake). Dewatering may take 4 to 6 weeks, with maintenance occurring after the lake is drained. This work would be performed every 15 years. The reservoir would be partially filled with dechlorinated potable water by Sonoma County Regional Parks to maintain a recreational lake. Sediments would also be removed at the Santa Rosa Creek intake structure of Spring Lake. This structure contains barriers and silt deflection structures to reduce the amount of material that goes from Santa Rosa Creek to Spring Lake. Sediments would be excavated from detention basins in the summer when the inlet is dry.

In Matanzas Creek Reservoir, the desiltation would begin in the late spring or summer, after inflows have stopped and the reservoir has dried back as much as possible. Fish rescues would be conducted and the fish transferred to Lake Ralphine (at Howarth Park), but anadromous salmonids would not be affected.

The Spring Creek diversion is a small diversion facility that reduces peak flows into Spring Lake. Desiltation is required behind the control structure of the diversion. Generally about 200 cubic yards, but as much as 500 cubic yards of material consisting mostly of gravel and sand, may be removed. This maintenance would occur approximately once every 5 to 10 years.

Small-scale (radius of 50 feet) silt, debris and vegetation removal would be performed as part of the structure maintenance work on the outfall of Brush Creek every 3 to 5 years along with regular mowing. Although sediment removal has not been needed in the past, it may be necessary in the future. Piner Reservoir has not been excavated in recent years, but sediment removal is likely to be needed in the future. Piner and Brush Creek reservoirs have small capacities, so sediment removal activities would take place later in the summer when the water has naturally evaporated. Paulin Creek would be maintained approximately every 15 years.

4.4.1.4 Sediment Maintenance and Channel Debris Clearing Practices

Sediment removal would be conducted with excavators with extended arms, and in some areas, with bulldozers and front-end loaders as well. Excavating equipment with a reach appropriate for the channel being cleared would be used. The equipment would be driven along the access road, and sediment removal would be done perpendicular to the channel length. Bulldozers would be used in high width/depth ratio channels where excavators cannot reach the channel bottom from the service road. A bulldozer would stockpile sediment to a closer area and then stockpiles would be removed with an excavator.

Sediment removal would be performed in the summer when the stream may be dry. However, if water were still flowing in the channel, streamflow would be diverted around the project. Alternatively, for small projects, barriers would be constructed upstream and downstream as necessary. The barrier would slow the flow of water, which would allow suspended sediment to settle out where it can then be removed.

In dry channels, a front-end loader, bulldozer, or excavator would be used in the channel bottom. A loader or excavator can load a dump truck in the channel bottom. The heavy equipment would be driven along the channel bottom after being driven in on an existing ramp, a temporary access ramp, or over shallow sides. Sediment and debris would be placed directly into dump trucks or semi-trucks on the channel bottom.

Before implementation of sediment removal activities, the sites scheduled for sediment removal would be evaluated by SCWA staff biologists to make any needed recommendations for protecting aquatic and riparian species and habitat. If the potential for salmonid species to occur in the area during the project is identified, sediment removal operations would be modified to include a fish rescue by staff biologists. Fish rescue activities have not been needed in the past because of the poor-quality habitat that exists in the channels that typically accumulate sediment.

Grade-control structures and fish ladders under SCWA's jurisdiction would be inspected annually, and cleared of debris, as necessary, to protect the structures. Hand labor or heavy equipment (i.e., excavator or backhoe) would be used to clear debris from structures.

Large debris would be removed from constructed flood control channels, flood control reservoirs, and to a very limited extent in natural waterways associated with emergency sediment maintenance and bank stabilization activities. It would be removed on an as-needed basis, as determined through the cooperative efforts of SCWA operations and maintenance personnel and fisheries biologists. Large woody debris would be allowed to remain in flood control channels if it does not threaten bank stability or the flow capacity of structures such as bridges and culverts. Large woody debris or other structures providing fish habitat would only be removed if the debris were causing a significant erosion problem or flow blockage. Large anchored jacks that have come loose from their original placements and are found in the Russian River channel would also be removed on an as-needed basis.

Before large woody debris would be removed, it would be evaluated by SCWA staff. If it is determined to be stable (i.e., not likely to be dislodged, washed downstream, and threaten the integrity of a structure), it would be left in place. For example, a piece of large woody debris was left in place on Brush Creek recently because it was downstream of the Highway 12 bridge and was not in a position to float downstream and cause a debris jam at any bridges. Loose pieces of large woody debris may be anchored in place if found in an area where they are not likely to pose a threat. If large woody debris appears in a constructed channel in downtown Santa Rosa, particularly if it is 20 feet or longer, it is likely to become lodged at a bridge and create a blockage. Large woody debris presenting this kind of threat to infrastructure would be removed. If large woody debris is determined to pose a hazard, it would be removed in consultation with CDFG and NOAA Fisheries. Large woody debris would be removed with a winch from the top of the bank, cut up with chain saws, and transported away. Brush would be chipped and put on landscaped areas.

4.4.2 VEGETATION MAINTENANCE

Vegetation maintenance on streambanks and within channels would be conducted by SCWA to maintain bed and bank stability on Dry Creek and the Russian River, and to maintain flood capacity for the natural waterways and constructed flood control channels. To meet the objectives of channel stability and flood control while protecting aquatic and riparian habitat, SCWA has refined its procedures for vegetation maintenance on constructed flood control channels and natural waterways (Tables 3-12 and 3-14). These practices, which differ significantly between the natural waterways and constructed flood control channels, are described below. SCWA has hydraulic maintenance easements that are permissive and allow SCWA to access various natural creeks to remove debris or vegetation to restore hydraulic capacity and to protect property. SCWA's proposed vegetation maintenance activities are described in more detail below.

Channel maintenance activities in the Russian River and Dry Creek performed under USACE obligation include both vegetation and sediment maintenance. These activities are discussed separately.

4.4.2.1 Vegetation Management in Constructed Flood Control Channels

SCWA maintains approximately 150 miles of constructed flood control channels (Table 3-12). Many of these channels were designed to provide 100-year-flood capacity. The original design capacity assumed that streambanks would be predominantly grass, with little or no tree growth, and the streambed would be maintained clear of vegetation and sediment.

Channel Capacity Assessment and Adaptive Management

A hydraulic assessment of selected Zone 1A constructed flood control channels was performed in 2000 to identify flood capacity under various vegetation management scenarios (Table 3-13) (ENTRIX, Inc. 2002a). The hydraulic assessment showed that for many of the channels, moderately dense shrubby vegetative growth with young developing willows (approximately 5 years old) on portions the streambank, and tule growth on the streambed, would cause impairment of hydraulic capacity, so that the 100-year flood might not be contained. To maintain original-design-flood capacity in these channels, it would be necessary for SCWA to keep vegetation from growing into a dense brushy stage. Should the amount of vegetation in these channels be greater than that described above, these channels would likely not be able to accommodate the flows necessary to prevent floods.

Additionally, SCWA is currently reviewing a preliminary hydrology study conducted by USACE (2002a). That study determined that 100-year-storm flows in the Santa Rosa Creek watershed are of a greater magnitude than had been historically calculated and used for the design of flood control channels.

SCWA is currently reviewing the recent USACE (2002a) draft hydrologic engineering report to determine the extent to which peak flood flows in the Santa Rosa Creek drainage exceed flood peaks used as the basis for the original design of the flood control channels. SCWA will also be performing additional hydraulic modeling to assess the capacity of its flood control channels.

If USACE analysis is verified, SCWA will evaluate various flood-control options to address the higher peak flows. Zone 1A flood control channels and flood detention basins will be assessed to see if they provide 100-year-flood protection. Revised channel maintenance practices, in combination with new or redesigned flood control facilities, may be necessary. The specific mix of options available to achieve flood protection would be evaluated based on a more detailed understanding of peak-flood magnitudes associated with each of the sub-basins contributing to the Santa Rosa Creek watershed, and the engineering feasibility of various design options. From the hydrologic and hydraulic modeling results, a range of opportunities will be investigated to determine whether there are feasible methods for reducing flood peaks in order to contain the 100-year flow.

The results of these technical studies will be used to form the basis of an adaptive management approach. The effects of vegetation management protocols on flood capacity would be monitored and evaluated to determine whether modifications to the protocols are appropriate. If a channel exhibits less capacity than modeled, additional measures would be implemented to improve capacity. If a channel exhibits greater flood capacity, the management protocols would be modified to allow more vegetative growth if needed to support habitat value of the channel.

Where feasible methods to reduce flood peaks are identified and developed, and adequate channel capacity can be maintained, SCWA would allow more mature or more dense vegetation to grow in the constructed flood control channels than is currently proposed.

Site-specific areas would be evaluated for ways to increase channel capacity while reducing effects to, or increasing habitat value for, salmonids. One option would be to lower one of the two service roads along a channel so that it becomes part of the high-flow channel, thereby increasing the cross-sectional area. A service road that is at the top of a levee or bank can be lowered by excavating a portion of the top of the bank, thereby increasing channel capacity. This action would be feasible only in channels that have a sufficiently wide right-of-way between the existing service road and the bordering fence-line to provide enough room for a stable bank after excavation and lowering of the service road. Lowering the service road would be considered only in areas that currently require frequent maintenance or where design-flood capacity is currently insufficient. The locations where the service road could be lowered and where this would be desirable to improve flood capacity would be identified and evaluated for potential modification. Increasing channel capacity in this manner could enable the creek to be managed with more mature riparian vegetation and a more natural geomorphic and ecological form.

In areas where it would be feasible, some of the bar features within the channel would be retained. This would occur while still maintaining adequate channel capacity, and where improved passage to upstream rearing or spawning habitat would be beneficial. Enough instream vegetation and/or sediment would be removed to maintain channel capacity, but some of the root structure would be left in place to stabilize the bars in the low-flow channel and maintain deeper water depth for fish passage.

Channel Maintenance Zones

To maintain constructed flood control channels, SCWA has apportioned the maintenance activities into five “zones”: top-of-bank, upper channel bank, middle channel bank, lower channel bank, and the channel bottom. Maintenance activities in top-of-bank and upper channel are consistent among all constructed flood control channels. Maintenance activities in the lower three zones (upper, middle, and lower channel bank) would vary depending on channel capacity and flood risk.

<u>Top-of-Bank</u>

The top-of-bank zone maintenance includes:

- landscape maintenance
- fence/gate maintenance
- V-ditch and drop inlet maintenance
- service road maintenance

The access roads for the constructed flood control channels would be kept clear of vegetation with the use of aquatic contact herbicides (which are effective only at the time of application [i.e., early spring]) and mowing. The portion of the channel between the access roadways and the fence lines that border the channels would be mowed twice annually for fire control purposes and structure integrity. In areas that do not contain access roads, an area of width 1.5 times the average height of the fuel source would be mowed adjacent to the fence lines. Mowing in this area would avoid native trees.

<u>Upper, Middle, and Lower Banks</u>

The upper and middle channel bank zones typically consist of the upper two-thirds of the channel bank (which is generally everything above 5 feet higher than the channel bed). The lower channel bank zone comprises the area in the lower third of the channel bank (typically lower than approximately 5 feet above the channel bed), including the toe of the channel.

Vegetation Maintenance Levels

The level of vegetation maintenance applied would depend on the hydraulic capacity required in the channel. One of three vegetation management practices would be applied, maintenance of the original design capacity, intermediate vegetation maintenance, or mature riparian vegetation maintenance.

Original Design Capacity Maintenance

In site-specific areas where the hydraulic assessment (ENTRIX, Inc. 2002a) indicates that simulated flows are near or just over-bank, vegetation would be maintained at the original-design-capacity scenario. SCWA would keep vegetation from growing into a dense brushy state. Vegetation maintenance practices may include limiting vegetation on streambanks to predominantly grass with little or no woody stem growth; maintaining the channel bottom clear of vegetation; and frequent maintenance.

Intermediate Vegetation Maintenance

In some channels, vegetation may be allowed to grow while still maintaining sufficient hydraulic capacity. These are generally channels that have required maintenance every 5 years or more. The following maintenance practices would apply.

Thinning of under-brush and debris removal would take place in the upper and middle zone. Existing mature trees, which are predominantly within the upper third of the bank or at the top-of-bank, would not be removed unless dead, diseased, or downed, and presenting a hazard to adjacent or downstream properties. The lower limbs of existing trees would be periodically thinned and removed to keep them above the floodway elevation (i.e., above top-of-bank).

Channel maintenance practices in the lower channel zone would consist of the removal of understory vegetation. Understory vegetation removal (e.g., blackberries) would be accomplished by hand-clearing and spraying of aquatic herbicides. Small, mechanized equipment may be used to transport the cut vegetation to the top-of-bank so that it may be efficiently removed from the channel. Removal of plants will be selective, based on the species present, with an emphasis on protecting native riparian species wherever possible. Native trees (typically willows) that are growing along the lower one-third of the bank, including the toe of the bank where it intersects the channel bed, would be allowed to colonize as young trees. These trees will provide shade and cover along the wetted channel bottom during the low-flow summer season. However, these young trees must be regularly maintained so that they do not cause significant impairment of flood capacity and do not provide an opportunity to catch woody debris during high-flow events. Therefore, the following guidelines will be used to maintain the young trees along the lower third of the bank:

- Certain species of willows (or other native riparian vegetation types such as cottonwoods and alders) would be allowed to grow to no more than one-half the total design depth of the channel.

  For example, a channel with a design depth of 20 feet may have willows that grow to a height of approximately 10 feet. Young trees that exceed one-half the depth of the channel would be cut and stump-treated with approved herbicides. Where possible, existing trees of 4 inches in diameter or larger may be retained in trade for removing smaller trees in the immediate area. Where hydraulic capacity would not be impaired, the growth of colonies of mature trees would be encouraged, spaced intermittently in the channel, or for shading adjacent to pools.

- All limbs growing out from the main trunk will be pruned as the trees grow so that the lowest limbs are at least 5 feet above the ground elevation.

- Any trees with more than one developing trunk will be pruned to a single main trunk. Because arroyo willows take a shrubby form, this particular species will be completely removed from the channel whenever they are identified. However, if other trees are not there, some willows may be left.

- Initial spacing between colonizing trees will be approximately 15 feet. If tree canopies begin to fill-out so that they are overlapping or touching, then the spacing between trees will be increased by thinning.

Mature Riparian Vegetation Maintenance

In some channels, complete canopy cover could be achieved by allowing the development of mature, single-trunk trees with most of the canopy above the floodway elevation. Native trees would be maintained (i.e., thinning or pruning) or planted. Vegetation at the channel toe and in the lower third of the bank would be maintained parallel with the flow and spaced 15 to 25 feet, depending on the species. Lower limbs would be pruned to maintain channel capacity. To achieve a mature canopy cover, adequate flood capacity must exist in the channel both during the period when young trees are growing within the floodway and at later mature stages when these trees have canopies that rise above the floodway elevation.

Mature trees and plantings would increase the riparian habitat value of the channel over original design capacity (baseline conditions) or intermediate vegetation maintenance. An example is the riparian corridor that has developed along a restored section of Brush Creek (Section 4.5.2.12). On this creek, trees were planted in a fairly straight line parallel to the stream, providing riparian vegetation while minimizing reduction of hydraulic capacity.

Channel Bottom

The channel bottom of constructed flood control channels would be cleared of vegetation through the use of spray aquatic contact herbicides and hand clearing. Future selected vegetation clearing from the channel banks may be necessary to allow access to the channel bottoms for silt removal operations. Small, mechanized equipment may be used to transport the cut vegetation to the top-of-bank so that it may be efficiently removed from the channel.

Level of Vegetation Management in Constructed Flood Controls

Table 4-6 lists the flood control channels and an estimate of the level of maintenance that would be performed (see Figure 3-5 and -6). This table shows that portions of some channels with potential salmonid habitat would require original-design-capacity maintenance practices, including Paulin, Piner, Santa Rosa, Brush, Crane, Laguna de Santa Rosa, Rinconada, and Todd creeks. Additional channels that require this level of maintenance may act as a migration corridor only. An adaptive management approach (described in Section 4.4.2.1) would be implemented to assess which channels may in the future have maintenance protocols that allow more vegetation to grow.

For bridges and culverts that do not have the capacity to pass the 100-year discharge under the intermediate maintenance, it would be necessary to implement original design

Table 4-6 Levels of Vegetation Maintenance Work in Flood Control Channels[1]

Creek	Summer Flow[2]	Species Known to Occur[3]	Potential to Support Spawning/Rearing Habitat
Streams that Require Original Design Maintenance Scenario			
Migration, Rearing, and Spawning			
Paulin	Yes	St	Yes
Piner			Yes
Santa Rosa	Yes	Co, St, Ch	Yes
Migration and Rearing			
Brush		St	Yes
Crane			Yes
Laguna de Santa Rosa	Yes	St	Yes
Rinconada	Yes		Yes
Todd		St	Yes
Migration Only[4]			
Austin[5]		St	Yes
Coleman			
Colgan			
Copeland			
Cotati			
Ducker			
Five			
Forestview			
Hinebaugh		Ch	
Kawana			
Lornadel			
Roseland			
Gossage / Washoe			
Wilfred	Yes		
Windsor	Yes		
Streams that Require Intermediate Vegetation Maintenance			
Migration, Rearing, and Spawning			
Oakmont	Yes		Yes

Table 4-6 Levels of Vegetation Maintenance Work in Flood Control Channels[1] (Continued)

Creek	Summer Flow[2]	Species Known to Occur[3]	Potential to Support Spawning/Rearing Habitat
Streams that Require Intermediate Vegetation Maintenance (Continued)			
***Migration Only*[4]**			
College			
Faught			
Hunter Lane Channel		St, Ch	Yes
Indian			
Peterson			
Russell			
Spivok			
Starr			
Steele			
Wendel			
Windsor tributaries			
Streams with Mature Riparian Vegetation Management			
Sierra Park			
Spring			
Wikiup			

[1]Source: SCWA (Paul Valente and Bob Oller, Maintenance Division).

[2]Summer base flow that is not supported by relatively recent urban runoff. Portions of these channels dry up in summer, but other portions retain base flow.

[3]Where rearing activity occurs, species are listed if known. Salmonids may use other channels currently or in the future. Co = coho salmon; St = steelhead

[4]Migration corridor assumed to be a function of all flood control channels.

[5]Austin Creek in Rincon Valley, not in West Sonoma County.

capacity vegetation maintenance practices near the bridge structures. These may include removing all vegetation except grasses within approximately a distance equal to the channel top-width both upstream and downstream from the bridge.

Since vegetation removal practices were modified in the last few years, significant tree growth has occurred on several engineered channels such as Brush, Santa Rosa, Copeland, and Hinebaugh creeks. This vegetation may need to be thinned, pruned, or removed.

SCWA also has vegetation maintenance responsibilities on a section of Santa Rosa Creek for the Prince Memorial Greenway restoration project and for a restoration project on the lower reaches of Brush Creek. In general, these responsibilities include maintaining vegetation that has been planted along the streambanks for each of these projects (on Brush Creek vegetation is not cut on the lower one-third of the streambank), so that there is no loss of the riparian canopy. SCWA is responsible for channel maintenance of these restored flood control channels and will implement the least intrusive maintenance protocol that provides flood protection.

4.4.2.2 Vegetation Management Practices in Natural Channels

For the natural channels (other than the Russian River and 15 channel improvement sites along Dry Creek) where vegetation removal may occur, SCWA does not have routine or regularly implemented maintenance obligations. Maintenance on natural waterways (Table 3-14) would consist of clearing vegetation from the bottom of natural waterways to restore hydraulic capacity. Hand labor is the typical clearing method. Heavy equipment would only be used to lift out or clear debris jams not accessible to hand crews.

One of SCWA's riparian enhancement project goals is to create a shade canopy over the stream channel, which reduces plant growth on the channel bottom, and in turn helps maintain hydraulic capacity. In accordance with this goal, native trees growing along streambanks have been allowed to establish. Some vegetation understory along the channel banks and in the main channel that could substantially reduce hydraulic capacity would be removed by mowing (upper third) or hand clearing, as needed. This practice would be implemented by SCWA staff, including both operations and maintenance personnel and staff biologists. SCWA staff may occasionally need to use herbicides (approved for aquatic use) and/or hand labor to remove invasive exotic species. Native vegetation would generally not be removed unless it presents a significant flood risk.

SCWA staff have observed, through various maintenance and riparian enhancement projects, the effectiveness of maintaining (thinning or pruning) or planting native trees along the streambank in a fairly straight line parallel to the stream. These trees and plantings have increased the riparian habitat value of the stream. This procedure for riparian enhancement plantings would continue to be implemented as part of SCWA's fisheries and riparian restoration projects in the Russian River watershed.

Vegetation control along the levee access roads of the Mirabel/Wohler diversion facilities would be done as needed using hand removal or an herbicide approved for aquatic use. Blackberries that grow in channels connecting the diversion at the Russian River with the infiltration ponds would be removed by hand once a year. Mowing on levee roads generally would occur in late spring each year.

4.4.3 Bank Stabilization in the Russian River and Dry Creek

SCWA and MCRRFCD were designated as the local agencies responsible for channel maintenance below Warm Springs Dam and Coyote Valley Dam, in Sonoma and Mendocino counties, respectively. SCWA's and MCRRFCD's bank stabilization activities on the Russian River and its tributaries would be limited to maintenance of past channel improvement projects. Several projects were implemented by USACE on the Russian River from RM 98 near Calpella to approximately RM 40 in Healdsburg. In addition to maintaining channel improvements installed for Coyote Valley Dam, SCWA and MCRRFCD would continue to inspect channel improvement sites that were constructed between 1956 and 1963.

MCRRFCD conducts channel maintenance in Mendocino County. MCRRFCD was the lead agency on two non-project levees under Public Law 84-99, located in Hopland on

Fetzer Vineyard properties and at the Calpella County Water District. USACE conducted annual inspections of these levees and, along with the landowner, was responsible for the repair of the levees. The Fetzer Vineyard and Capella County Water District sites are now out of the active USACE program.

Maintenance activities would be proposed by USACE, SCWA and MCRRFCD, and a letter submitted to NOAA Fisheries annually for review and response. Projects would be designed in consultation with NMFS and CDFG, and would conform to authorized take limits set in the Incidental Take Statement issued by NOAA Fisheries.

Dry Creek

Channel maintenance activities on Dry Creek are limited to maintaining USACE channel improvements at 15 locations that were installed to prevent bank erosion following construction of Warm Springs Dam. These improvements are identified in the USACE operation and maintenance manual prepared in July 1991 (USACE 1991). Under the proposed project, SCWA would continue to maintain these 15 channel improvement sites. Maintenance work associated with these sites can involve incidental sediment removal, vegetation removal, removal of debris, and bank stabilization. Vegetation removal would only occur to improve bank stability if trees are leaning or otherwise directing high flows against the bank, causing erosion, and to visually inspect a bank stabilization structure. Bank stabilization work typically would involve replacing lost riprap and, if necessary, regrading the bank slope to its previous contours in order to provide a stable base for the riprap. Riparian vegetation on the channel banks and bars would be left in place, if not threatening bank stability, to maintain shade for aquatic habitat.

Outside of the work done on the 15 grade and bank erosion control structures, additional vegetation removal for flood control or bank erosion is not a USACE obligation and would not be performed in Dry Creek. However, limited work may be performed in Dry Creek, specifically at landowner request in response to extreme flood flows that result in bank erosion that threatens property or structures. This type of work would occur infrequently.

SCWA would continue to inspect the one nonfederal levee (Public Law 84-99) on Dry Creek. The property owner is responsible for needed repairs.

Russian River

Under the proposed project, SCWA and MCRRFCD channel maintenance activities would be conducted in the Russian River. USACE and SCWA would periodically inspect the channel improvement sites and levees. USACE would then recommend maintenance work that may be needed. In general, SCWA and MCRRFCD would be required to keep the project levees free from vegetation, remove instream gravel bars that may be impeding flow, and inspect and maintain the channel improvement sites. Typical maintenance activities for channel improvement sites in the Russian River are similar to those on Dry Creek, and include removing loose anchor jacks from the river, repairing and replacing loose grout or riprap, adding bank erosion protection at sites found to be eroding, and managing vegetation and removing flood debris to reduce blockage of the river channel that is causing bank erosion or preventing inspection of channel improvement sites.

Repairs to bank stabilization structures in Dry Creek and the Russian River would be as needed when identified during USACE inspections, and would employ BMPs to minimize disturbance to listed species during construction activities. Large anchored jacks that have come loose from their original placements and found in the river channel would be removed. Vegetation removal at bank stabilization structures would only occur if vegetation threatens the integrity or function of a structure. Sediment removal would be conducted to prevent flows from being directed toward a bank that is eroding.

SCWA would conduct inspections of nonfederal levees, but if major repairs were needed, the property owner and USACE would be notified.

4.4.3.1 Gravel Bar and Overflow Channel Maintenance in the Mainstem Russian River

Under the proposed project, MCRRFCD would perform streambank maintenance consisting of obstacle removal, streambank repair, and preventive maintenance over a 36-mile reach of the Russian River in Mendocino County. SCWA would perform streambank maintenance in the mainstem Russian River in Sonoma County. However, gravel bar grading activities under the proposed project would be more limited than under baseline conditions, and protocols would be implemented to reduce the potential for negative effects on salmonid habitat.

Conservation measures provided in the terms and conditions of BOs issued by NOAA Fisheries to Syar Industries and Shamrock Materials, Inc. for instream gravel mining operations, as well as measures in the ARM Plan, may be useful to implement in the proposed project for bank stabilization work in the Russian River. However, streambank stabilization is very different from gravel extraction, and, therefore, conservation measures will differ as well.

Bank erosion occurs when flow is directed into the riverbank by large gravel bars that are often well vegetated. To reduce bank erosion in the mainstem Russian River, instream gravel bars that contribute to bank erosion would be regraded, and overflow channels would be created to direct the river channel away from susceptible banks. Maintenance work would be directed toward reshaping and removing a portion of these bars. This action specifically addresses sites where the formation or growth of gravel bars is likely to cause severe bank erosion.

MCRRFCD has identified approximately 23 sites along the river in Mendocino County that have required maintenance work in the past (B. Spazek, pers. comm. 2003). Areas identified as problem areas are usually located at curves in the river. Three to four sites have been worked on annually. The selected sites ranged in size from very small areas to reaches up to 100 yards long. Under the proposed project, MCRRFCD would continue to assess approximately 12 miles of river each year and would limit the site size to between

10 feet and 300 feet in length. Up to three or four sites would continue to be selected on the basis of need for streambank erosion control. CDFG staff would continue to participate in site visits and evaluate site selection.

SCWA would also limit this maintenance work in the river in Sonoma County to no more than three to four sites per year.

Protocols would be implemented to reduce effects to salmonid habitat. The gravel bar grading protocols are listed in the following section.

USACE would, in cooperation with NOAA Fisheries and CDFG, review the sediment and vegetation control obligations contained in the USACE O&M manuals and modify them to minimize the effects of channel maintenance activities on listed fish species. These modifications would be identified in the Section 404 permits required for the channel maintenance activities.

MCRRFCD would continue to assist property owners with bank stabilization on the Upper Russian River in Mendocino County by being the lead agency, when necessary, for obtaining public law funding when major bank failures have occurred. MCRRFCD would also encourage property owners to stabilize their banks by planting native vegetation along the banks to reduce erosion.

Gravel Bar Grading Protocols in the Russian River

Certain conditions may warrant some degree of channel maintenance. Channel maintenance activities may be conducted if one or more of these conditions exist:

- Occurrence of severe bank erosion.
- Recent substantial changes in channel morphology that are likely to lead to severe bank erosion.
- Evidence of weakened levees.
- Threats of flooding to infrastructure or private property.

Bank erosion is a natural process, where a dynamic balance between the dominant discharge and the sediment load determines the sinuosity and slope of the river channel. In equilibrium, a meandering channel develops, where bank retreat opposite the bars is, on average, balanced by deposition at the inside of bends. Gravel bar grading may be implemented if there is evidence of severe bank erosion, or recent substantial changes in channel morphology suggest that severe bank erosion is likely during the next rainy season. As a general guideline for this BA, “severe bank erosion” is characterized as a substantial loss of streambank material. Although the characterization of severe erosion is likely to be site-specific, an example of how severe bank erosion may be defined is the loss of streambank material that, measured in the vertical, is approximately equivalent to three-quarters of the total bank height and continuously extends for at least 200 linear feet (lf) along the channel.

Gravel bar grading would be conducted in a manner that provides increased protection for the low-flow channel and native vegetation, and reduces the need for channel bar grading. A qualified fish biologist would evaluate the habitat and biological features of each proposed site prior to implementation of grading. Project planning would be coordinated with NOAA Fisheries and CDFG.

The maintenance work would consist of grading bars in the channel during the dry summer season during low-flow periods and creating an overflow channel if needed. Maintenance work would occur between July 1 and October 1 to avoid spawning and incubation periods.

No grading would be conducted in the low-flow channel. Buffers (i.e., areas of undisturbed habitat) would be maintained along the edge of the low-flow channel to help maintain bar form, prevent deposition of material into the river, and to keep heavy equipment out of the wetted channel. A buffer width of at least 25 feet or 10 percent of the maximum bar width, whichever is less, would be maintained along the edge of the low-flow channel, whether vegetation is present or not. A buffer of 25 feet or 10 percent of the maximum bar width, whichever is less, would be maintained along the bank/levee side of the bar to reduce erosion along the bank.

If a channel bar is graded, the elevation of the post-graded bar would be at least 1.5 feet higher than the elevation of the edge of the low-flow channel to maintain the thalweg of the channel. Sediment would be contoured to create a slope that runs up and away from the centerline of the main low-flow channel that is at least a 2 percent grade from the water surface elevation at low flow, or baseline elevation at the water surface, whichever is higher. The slope parallel to the flow of the river would be consistent with the adjacent stream grade.

Openings would be provided on the upstream and downstream ends of the bar on the buffer zone to provide even drainage and to decrease the risk of juvenile salmonid stranding when high flows recede.

Any large woody debris that is moved or extracted would be deposited either on the upstream buffer area or along the low-flow channel buffer where it can be redistributed in the high flows of the next rainy season. If it poses a risk to property, it may be anchored or placed elsewhere in the river.

This work would be primarily performed using heavy equipment, such as front-end loaders, an excavator with an extended arm and thumb as well as an appropriately sized bulldozer. Equipment fueling and maintenance would be conducted outside of and away from the river channel. Because gravel bars do not always form in the same river sections over the years, new access roads may be required. Where possible, existing access roads would be used, and construction of new access roads would be limited to the fullest extent possible. Road widths would be limited to a width that allows one vehicle to pass. If needed, up-slope sediment control measures such as silt fences would be installed to reduce sediment input to the stream channel.

Gravel bar grading would be limited to that material necessary to reduce the risk of bank erosion. If necessary, gravel would be removed from the channel. Gravel removed from the lower Russian River may be relocated to Dry Creek (on USACE property at the head of the creek) as part of restoration activities, after written notification of and approval by NOAA Fisheries. An assessment would be made of how much gravel could be placed in Dry Creek without altering channel morphology. If future restoration actions in the East Fork or the mainstem upstream of the Forks require gravel supplementation, gravel could also be made available for those projects as well.

It should be acknowledged that natural riverine processes may tend to redeposit gravel and other sediments in areas that have been graded, and that ongoing maintenance may be needed. However, the goal of this action is not to stop re-formation of gravel bars, but to manage them in such a way to reduce the risk of extensive bank erosion that accompanies bar development. Section 4.4.3.3 describes a monitoring program that will identify areas subject to frequent or extensive maintenance and outlines potential alternatives to address bank erosion at those sites.

4.4.3.2 Vegetation Maintenance in the Mainstem Russian River

Under the proposed project, MCRRFCD would continue to perform vegetation maintenance to control bank erosion. Vegetation would be removed from gravel bars that contribute to bank erosion, implementing the following protocols that limit the potential for negative effects on salmonid habitat.

Vegetation Maintenance Protocols in the Russian River

Vegetation maintenance work may be conducted if one or more of these conditions exist:

- Encroachment by *Arundo donax (Giant Reed)* or other exotic pest plant species.
- Occurrence of severe bank erosion.
- Recent substantial changes in channel morphology that are likely to lead to severe bank erosion.
- Evidence of weakened levees.
- Threats of flooding to infrastructure or private property.

Invasive plant species like *Arundo donax* may be burned in place or uprooted and destroyed outside of the river channel. *Arundo donax* may be mulched using equipment appropriate for this species. In areas where infestations are extensive, heavy equipment such as backhoes, front-end loaders, and bulldozers may be used. Alternatively, *Arundo* may be cut off near ground level and the stump treated with an appropriate, approved herbicide. If effective new treatments are developed in the future for *Arundo* control, they may be implemented. The objective of these treatments is to kill all *Arundo donax* to prevent recolonization by plant tissue.

Vegetation maintenance may be conducted in conjunction with gravel bar grading activities related to streambank erosion control. Vegetation maintenance activities would be conducted in a manner that provides increased protection for the low-flow channel and native vegetation, and reduces the need for channel bar grading. A qualified fish biologist would evaluate the habitat and biological features at each site before implementation of vegetation removal. Project planning would continue to be coordinated with CDFG.

The vegetation maintenance work would be implemented during summer season low-flow periods between July 1 and October 1 to avoid salmonid spawning and incubation periods.

Vegetation removal would occur in a managed zone consisting of an area outside of the low-flow channel and outside a 25-foot vegetation buffer zone next to the low-flow channel. In channels that are wider than 200 feet, a vegetation buffer zone of at least 50-feet-wide would be maintained.

Vegetation in the buffer zone along the low-flow channel may be cropped. Vegetation that is too large to mow would generally be removed by hand. However, if removal of willows and other vegetation in the managed zone cannot be feasibly accomplished through mowing or hand removal, other heavy equipment such as bulldozers may be used. To the extent possible, mechanical methods that leave roots of native species intact would be selected to minimize sediment re-suspension and changes to gravel bar morphology during high flows. In some cases, more aggressive practices may be required to reduce the frequency of vegetation maintenance. In these cases, stumps of larger trees may be treated with contact herbicides, or willow roots may be removed.

Native vegetation that is removed in the management zone would be relocated to the extent possible. The removal of vegetation would include the subsurface material including the root structure. Any vegetation removal that requires gravel bar grading would implement gravel bar grading protocols outlined in the preceding section.

Vegetation removal would be scheduled so that gravel bars are worked on in rotation over a course of 3 to 5 years. Gravel bars would be assessed to identify those that require work. These gravel bars would then be scheduled for work during different years. Once a gravel bar has been worked on, it would be left alone for 3 to 5 years before it is worked on again. In this way, some bars would always have willows that provide high-flow velocity refuge areas for salmonids.

4.4.3.3 Site-Specific Bank Stabilization in the Russian River

Areas along the mainstem Russian River where frequent and/or extensive channel maintenance actions are required to prevent bank erosion would be identified. This information could then be used to assess whether these sites may be candidates for bank stabilization projects.

The location, frequency, and extent of channel maintenance work would be recorded as work is conducted. If specific areas require maintenance work involving gravel bar grading and construction of an overflow channel on a frequent basis (e.g., 3 out of 5 years), the potential to use other bank stabilization methods would be evaluated. SCWA or MCRRFCD would not be required to install bank stabilization projects other than bank revegetation. Where appropriate, revegetation plans to enhance the riparian habitat and bank protection would be limited to planting of native riparian species.

SCWA or MCRRFCD may coordinate potential bioengineered or engineered bank stabilization projects with local landowners or with the USACE, if persistent and severe bank erosion is identified in areas that threaten the integrity of structures and property. SCWA or MCRRFCD may be the lead agency on public-law funding when major bank failures occur. NOAA Fisheries would be notified of proposed bank stabilization structures and a request for approval would be made. If more than 1,000 feet of channel are to be affected by any single project or if the project is within 1,000 feet of a previously armored site, a separate ESA Section 7 consultation would be initiated for that action associated with the respective USACE 404 permit. The intent is to avoid large segments of continuous hard-armoring within the mainstem from cumulatively developing. If bank stabilization activities are implemented, bioengineered structures would be used whenever possible. Where bioengineered bank stabilization methods are not deemed to be practical, then priority would be given to incorporating vegetative plantings into the hard-armoring techniques that are implemented. Fish habitat restoration elements (such as native material revetments) would be incorporated into bank stabilization practices when feasible, with the intent of replacing lost habitat.

Installation of engineered, hard-armor bank stabilization structures may increase the risk that future streambank erosion problems may appear upstream or downstream of the bank stabilization site. Therefore, it may be preferable to implement gravel bar grading and overflow channels on a regular basis at some sites, rather than to implement hard-armoring bank stabilization projects.

4.4.4 Bank Stabilization in Natural Waterways

Through the FEP, SCWA has worked with local landowners to implement bioengineering projects to assist with bank erosion problems. This change in bank stabilization procedures has assisted landowners in protecting the streambank and has improved riparian and fisheries habitat along the Russian River and its tributaries. Examples of SCWA projects are provided in Section 4.5.

Occasionally, bank stabilization and sediment removal would be performed on natural waterways, including the Russian River, in response to bank erosion after unusually large storm events at the request of the landowner. In recent years, this type of work was performed on Austin Creek and Big Sulphur Creek.

The Big Sulphur Creek work serves as an example. In September 1995, SCWA was the local sponsor for a project to remove sediment from the channel, which had aggraded approximately 8 to 10 feet due to landslides the previous winter. In October 1997, another sediment removal project was necessary following the large storm events in January 1997. In both cases, the channel aggradation posed a significant flood risk to the surrounding area; thus, the activity was treated as an emergency repair action.

Potential activities would include bank stabilization, levee repair, vegetation or sediment removal, or channel realignment. These activities would be initiated only by a request from a private landowner after a washout threatens property or structures. Based on past history, such activities occur approximately once every 5 to 10 years. Typical project lengths under these circumstances are approximately 500 feet, but could be up to 1,000 feet. SCWA would not implement bank stabilization or sediment removal activities in natural channels if more than 1,000 feet of channel would be affected by any single project. As described earlier, a separate ESA Section 7 Consultation would be initiated for actions that affect more than 1,000 feet of channel or would be within 1,000 feet of a previously armored site.

Potential direct and indirect effects of a project to salmonid habitat would be considered during project planning and efforts made to reduce adverse effects to listed species. Construction would occur during the summer to avoid spawning and egg incubation periods. Before any activity is implemented, the site would be assessed with a qualified fisheries biologist. Feasible alternatives would be considered, and plans would be developed in consultation with CDFG. The planning phase would include an assessment of habitat and biological resources in the area, and consideration of those factors that may have contributed to the washout or sediment deposition.

Bioengineered bank stabilization methods would be given priority on smaller channels (less than 50 feet wide), when they are deemed to be a feasible and effective treatment. In larger channels were bioengineering techniques would not be feasible or effective, riprap or other hard-armoring measures may be used. Vegetative plantings would be incorporated into these bank stabilization measures as feasible. Fish habitat restoration elements would be incorporated into bank stabilization measures where feasible. Examples of such measures include the use of native material revetments, which combine boulders, logs, and live plant material to armor a streambank (as outlined in Flosi et al. 1998). Revegetation with native plant species would always be implemented in association with bank stabilization measures if site conditions are suitable.

As part of bank stabilization efforts, it is also sometimes necessary to remove deposited sediments or vegetation growing on bars. Preference would always be given to thinning vegetation on gravel bars, which allows gravel to move over time so that it does not have to be excavated with heavy equipment. However, bars would be removed if necessary to prevent erosion that would occur if flows are directed into vulnerable streambanks by the bar deposit. If large woody debris is present in the excavated sediment deposits, it would be removed from the stream only if it threatens to de-stabilize a section of streambank. Otherwise, the large woody debris would be allowed to remain in the channel. On occasion, it is preferable to straighten a short portion of the channel by cutting off a meander instead of excavating the bar sediments if the bank cannot be sufficiently stabilized by other means. If this realignment practice is used, SCWA would consider replacing any lost habitat by incorporating native material revetments as discussed above.

Standard BMPs would be applied to work in natural channels. If possible, sediment excavation and bank stabilization would be performed under low-flow conditions, generally during the summer or fall months. If the channel is not dry, flows would be diverted, typically using earthen cofferdams, pea gravel, or, if necessary, a clean bypass. A fish biologist would inspect the reach where dewatering must occur to allow in-channel work. Fish rescues would be conducted, if necessary. Work would be performed using heavy equipment, which may include backhoes, excavators, and dump trucks, depending on the site configuration and available access. BMPs for operating equipment in or near an active channel would be followed as outlined in Section 4.4.1.4.

4.4.5 Gravel Bar Grading in the Mirabel/Wohler Diversion Area

Gravel bar grading would continue to be conducted in the Russian River near the Mirabel/Wohler diversion areas. The protocols for gravel bar grading operations conducted to increase infiltration capacity may differ from those conducted for channel maintenance. Therefore, these activities are discussed separately.

Infiltration capacity at the Wohler and Mirabel diversion facilities would be augmented by periodically recontouring three gravel bars in the Russian River upstream of the inflatable dam (Wohler, McMurray, and Bridge gravel bars) and excavating one bar (Mirabel Bar) downstream of the inflatable dam near the Mirabel infiltration ponds. Work in other gravel bars may be required in the future if the pattern of gravel bar formation in the river changes so that new bars are formed. These would likely be located between the proposed Caisson 6 and Caisson 3. The McMurray and Mirabel bars are approximately 1,000 feet long and 200 feet wide. The other two gravel bars are approximately 500 feet long and 100 feet wide.

The gravel bars would be graded to lower the level of the streambed so that the area is flooded when the inflatable dam is raised. Gravel bar skimming operations would be performed outside of the active low-flow channel on the Wohler, McMurray, and Bridge gravel bars in the spring of each year (or as needed) when streamflows drop below 800 cfs, and before the dam is inflated. When this work would be performed would vary, depending on the flow in the river and demands on the water system, but would generally occur between March and July.

At the Mirabel Bar, a barrier would be first constructed to prevent water from flowing through the area to control sediment. In addition, sediment fences would be used to prevent the input of sediment into the river. The Mirabel gravel bar would be excavated between July and October, depending on flow conditions.

Gravel at these locations would generally be pushed up on the bank using bulldozers and scrapers; in the future some may be removed and stockpiled outside of the floodplain. The material from the Mirabel gravel bar would be removed and hauled away. The largest of these bars (McMurray Bar) forms approximately 2,000 feet upstream of the Wohler Bridge near the mouth of Porter Creek. At flows above 800 cfs, the McMurray Bar is not accessible. There is a secondary channel between the McMurray Bar and the northern bank. When the water level in this secondary channel drops below approximately 3 feet at the crossing point, equipment would be moved out onto the bar to conduct grading operations.

The Bridge Bar is located on the north (Mirabel side) bank of the river near the Wohler Caissons. A second smaller bar located near SCWA's Mirabel collectors is also skimmed each year. The Wohler gravel bar is located on the eastern shore of the Russian River near Caisson Number 1. Gravel at this bar would either be pushed into piles along the banks, or removed from the bar using scrapers and placed in a stockpile located between Caisson 2 and Wohler Bridge. The Mirabel Bar is located near Caisson 3 on the northern side of the Russian River. Gravel from this bar would be removed, using bulldozers and scrapers, and placed in a stockpile north of infiltration pond number 1, shown in Figure 4-3. Gravel from both the Mirabel and Wohler stockpiles would be removed by gravel contractors.

After gravel bar grading operations on the Mirabel bar are completed, the gravel bar would be contoured to reduce the potential for fish stranding. The elevation of the post-graded bar would be at least 1.5 feet higher than the elevation of the edge of the low-flow channel to maintain the thalweg of the channel. Sediment would be contoured to create a slope that runs up and away from the centerline of the main low-flow channel at a 2 percent grade from the low-flow water surface elevation, or baseline elevation at the water surface, whichever is higher. The slope parallel to the flow of the river would be consistent with the adjacent stream grade. This practice could be implemented on other bars in the future if needed.

The spoils from the gravel bar grading operations would be mounded in the riverbed. If the gravel volume is very large, spoils may have to be relocated or stockpiled outside of the floodplain. The sediment size varies from year to year but generally consists of sands and gravels. The operation would be done during the dry season (e.g., July in 1999), and, if necessary, a cofferdam would be built to keep water out of the work area. The cofferdam would be breached to let water in once the sediment is removed.

The area and volume of sediment removed from the gravel bars would vary from year to year. In summer 1999, approximately 6,500 cubic yards of gravel were removed in the Mirabel area and in 1998, 1,650 cubic yards. In 1999 in the Mirabel area, two D-6 Cats, a motor grader, and a water truck for dust control were used. The equipment entered the bar from the west bank.

The following BMPs for gravel bar grading operations were evaluated by SCWA during a 5-year monitoring study (Chase et al. 2000) and will be implemented as part of the proposed project.

- Biological oversight will be provided by fisheries biologists. SCWA biologists will inspect the gravel bars before beginning gravel skimming work to a) evaluate the need for silt fences, and b) identify environmentally sensitive areas.

- Permanent vegetation on the riverbanks may in some cases be thinned to allow equipment access to the bar, but will not be removed.

- Sediment fences will be employed to prevent the input of sediment into the river.

- Cofferdams will be constructed both upstream and downstream of the work areas, if necessary, to allow access to the work areas.

- Operation of heavy equipment in the active stream channel will be limited to moving equipment to and from the mid-channel gravel bars and breaching cofferdams when needed, and will be very short in duration. All equipment will be removed from the gravel bars at the end of each day.

- No fueling or equipment service will be performed on the gravel bars or within the active floodplain.

- Gravel skimming operations will be limited to material above the waterline.

- After gravel bar grading operations are completed, gravel bars will be contoured to at least a 2 percent grade to reduce the potential for stranding fish.

- Continuously recording turbidity meters will be installed upstream and downstream of gravel bar grading operations.

Breaching of the lower berm for the Mirabel Bar will be conducted late in the evening or early in the morning to reduce visual effects to recreational visitors at Steelhead Beach.

4.4.6 NPDES Permit Activities

Several activities are undertaken by SCWA, the City of Santa Rosa, and the County of Sonoma as co-permittees for a Phase I National Pollutant Discharge Elimination System (NPDES) Municipal Separate Storm Sewer permit. The 5-year permit was renewed by the NCRWQCB on June 26, 2003, and encompasses a larger area than was included under the first permit term. The largest part of the new boundary of permit coverage is approximately coterminous with the SCWA flood control Zone 1 boundary, which defines the Mark West Creek and Laguna de Santa Rosa Watersheds. All creeks within Zone 1A, as listed in Table 4-7, are subject to this NPDES permit. Two areas outside Zone 1A are also included in the permit boundary: the community of Graton and a small unincorporated area outside of the City of Healdsburg. Only two SCWA flood control channels, Norton Slough and portions of Dry Creek from these other areas, are included within the permit boundary.

Table 4-7 SCWA Flood Control Channels within NPDES Boundary (Portions Thereof)

Austin Creek	Hunter Lane Channel	Moorland Creek	Santa Rosa Creek
Brush Creek	Indian Creek	Oakmont Creek	Sierra Park Creek
Coffey Creek	Kawana Springs Creek	Paulin Creek	Spring Creek
Colgan Creek	Lornadell Creek	Piner Creek	Steele Creek
College Creek	Matanzas Creek	Roseland Creek	Todd Creek

SCWA, the City of Santa Rosa, and Sonoma County have undertaken the following actions related to stormwater discharge under the NPDES permit, many of which benefit listed salmonids:

- The County Board of Supervisors' adoption of a Vineyard Erosion and Sediment Control Ordinance (VESCO) that will help protect creeks.
- Collection of composite and grab samples for chemical analysis during storms to evaluate possible trends of specific constituents.
- Enforcement of existing and new development standards to protect creeks and prevent erosion.
- Outreach efforts undertaken to educate the automotive industry, construction industry, landscape industry, carpet cleaners, high schools, colleges, and food service businesses in pollution prevention and BMPs.
- SCWA implementation of an education program for students and teachers about local watershed issues, pollution prevention, and stream protection.
- Presentation of erosion control seminars to local homebuilders.
- Improvement of responses to spills in storm-drain facilities within the NPDES permit boundary.
- Improvement of the City of Santa Rosa storm-drain cleaning system by implementing a dedicated maintenance crew and computerizing the cleaning tracking system.
- Stream cleanup efforts, including removal of shopping carts, trash, tires, car batteries, mattresses, and other large items.
- City of Santa Rosa implementation of an Integrated Pest Management (IPM) Program that includes a reduction in the use of pesticides. Herbicide use has also been reduced through the use of non-chemical vegetation control methods (e.g., weed mowers, hoeing, hand pulling, and mulching).
- Joint SCWA and City of Santa Rosa implementation of a creek stewardship program.

4.5 Restoration Actions

SCWA has implemented, and would continue to implement, many actions that are designed to contribute to the restoration of natural resources in the Russian River watershed, particularly resources of benefit to species listed under the ESA. These efforts include support for state and federal recovery plans; watershed management activities; riparian and aquatic habitat protection, restoration, and enhancement; and water conservation and recycling.

SCWA commits substantial funds, staff, and equipment to these restoration projects. SCWA has spent approximately $800,000 per year on its Natural Resources program, approximately 30 to 40 percent on monitoring at the Mirabel and Wohler diversion facilities (which has yielded valuable information about how listed fish species use the watershed), approximately 50 percent on FEP projects, and approximately 10 percent on meetings. Additionally, SCWA commits in-kind contributions of staff and equipment to restoration projects. For example, the in-kind contribution for restoration work on Big Austin Creek was $7,000 and on Copeland Creek was $31,000. SCWA secured an additional $471,000 in grants in 2000, and additional grant money will be pursued in the future.

To maximize the effectiveness of the dollars invested, SCWA develops project priorities on a basin-wide level, in cooperation with CDFG, other agencies, and private interests in the watershed. SCWA would work to implement priorities and recommendations outlined in the CDFG Draft Basin Restoration Plan for the Russian River Basin (CDFG 2002). Partnerships with other stakeholders in the watershed have been instrumental to the success of SCWA restoration projects and programs. SCWA would expand the indirect beneficial effects of restoration projects by using all available opportunities for public education.

Restoration activities would be proposed by USACE and/or SCWA and a letter submitted to NOAA Fisheries for review and response. Projects would be designed in consultation with NMFS and CDFG, and would conform to authorized take limits set in the Incidental Take Statement issued by NOAA Fisheries.

Actions that were implemented prior to the time the MOU was signed (December 31, 1997) are part of the baseline and were outlined in Section 3.7. Actions proposed or implemented since the MOU signing are part of the proposed project and represent an improvement to baseline conditions. Further details on these actions are provided in the sections below.

4.5.1 WATERSHED MANAGEMENT

SCWA would continue to take a proactive role in restoration and enhancement projects, and stewardship of the watershed. Several specific projects related to SCWA's contributions to watershed management efforts in the Russian River basin are described below.

4.5.1.1 Resource Conservation District Assistance

SCWA has contributed funding for Resource Conservation Districts in the Russian River watershed to develop and implement a Watershed Management Plan. This plan is intended to be a voluntary, watershed-based, locally-driven program to assist the agricultural and grazing community in complying with federal and state endangered species and water quality laws, including the protection of threatened fish species and their habitats. The watershed planning efforts will address soil and water conservation, including the improvement of farm irrigation and land drainage, erosion control and flood prevention, and coordination with community watershed groups. The plan will conform with city and county general plans that are applicable to the Russian River watershed area. In addition, the plan will incorporate the watershed planning needs identified by NOAA Fisheries in notices associated with the listing of coho salmon, steelhead, and Chinook salmon. For example, the listing notice for coho salmon stated that NOAA Fisheries will work with federal, state, and local agencies, including the California Association of Resource Conservation Districts, to develop and implement planning efforts, and that both technical and financial assistance will be made available to farmers in high-priority watersheds.

One program that SCWA has assisted Sotoyome Resource Conversation District with implementing is the "Fish Friendly Farming" program. This program is a voluntary, incentive-based certification program to address recovery efforts of the listed fish species. A technical advisory committee that consisted of grape growers, vintners, farming organizations, environmental organizations, and government officials worked together to develop a set of BMPs aimed at restoring and enhancing the fish habitat in the Russian River watershed. The BMPs focus on conserving soil and restoring and sustaining fish habitat on agricultural property. Program participants use a workbook to evaluate and assess their property and current growing practices, and to create a conservation plan for their property. NOAA Fisheries, CDFG, and NCRWQCB review the plan and the site, and the grower can receive certification as a "fish friendly" grower.

4.5.1.2 North Bay Watershed Association

SCWA is also participating in the North Bay Watershed Association (NBWA), which has been created to bring together government agencies within the San Pablo Bay watershed to discuss issues of common interest and concern. Such issues include Total Maximum Daily Load (TMDL) regulations, ESA compliance, habitat restoration, recycled water use, NPDES permits and studies, pollution prevention, source water protection, public education, and others. The NBWA will be a forum to allow local entities to:

- Work cooperatively and effectively with other agencies on watershed-based regulations and issues.
- Explore coordinated efforts on projects to leverage limited funding and resources, thereby decreasing project costs and increasing project benefits.
- Maximize success in securing state and federal grant funding for new watershed initiative programs.
- Efficiently share information about projects, regulations, and technical issues.

The NBWA can serve as a forum to find ways to increase the effectiveness of habitat restoration projects implemented by the participants. A watershed group, such as the NBWA or the Russian River Watershed Association, can seek opportunities to jointly develop habitat restoration projects to reduce costs and increase the ecological benefits to areas important to listed species.

4.5.1.3 Russian River Watershed Council

SCWA has also contributed to a watershed community council within the Russian River watershed region that has been established by the California Resources Agency and USACE. SCWA has provided a meeting place and refreshments, staff time, and other miscellaneous contributions, and has published updates in the *Russian River Bulletin*. The mission of the Russian River Watershed Council is to protect, restore, and enhance the environmental and economic values of the watershed.

4.5.1.4 KRIS/GIS Database

SCWA is contributing to the North Coast Watershed Assessment Program (NCWAP) by developing the Klamath Resource Information System (KRIS) coverages and developing selected Geographical Information System (GIS) layers for several watersheds on the North Coast, including the Russian River watershed. The KRIS/GIS will develop management tools for NOAA Fisheries and CDFG that facilitate salmon and steelhead conservation and recovery planning in NOAA Fisheries' North-Central California Coast Recovery Planning Domain ("planning domain").

The KRIS is a Windows®-based or Internet-based computer program that allows easy access to data tables, charts, photographs, and bibliographic materials relevant to fisheries, water quality, and watershed management. The KRIS can be adapted to any watershed to track factors that affect fish production and water quality over time and across watershed locations. ArcView GIS projects are an integral part of the KRIS program. GIS provides spatially referenced information that is displayed graphically and can be overlaid in conjunction with other spatial or temporal information. GIS "layers" are used in the KRIS to develop overlays and facilitate analysis of factors potentially limiting salmon and steelhead conservation and recovery.

The North Bay KRIS/GIS will provide an organized and easily-accessible computer-based collection of technical information that can be used by NOAA Fisheries and CDFG as well as other groups working in the region to assist in the definition, implementation, monitoring, evaluation, and adaptive management of measures intended to increase the numbers of naturally reproducing salmon and steelhead in the planning domain. The project will incorporate existing GIS data layers pertinent to salmon and steelhead recovery as well as develop new layers to augment the recovery planning process. Existing digital and nondigital databases, relevant watershed literature, and bibliographic reviews will be reviewed and compiled to identify pertinent data that need to be digitized and/or incorporated into the KRIS information management tools. Data layers identified as necessary for evaluating salmon and steelhead restoration, conservation, and recovery planning efforts will be digitized and incorporated into the KRIS projects based on priorities established by CDFG, NOAA Fisheries, NCRWQCB, and other applicable state and local organizations in the planning domain. The project will be coordinated with other ongoing GIS and KRIS efforts in the planning domain to avoid duplication of effort.

SCWA is providing funding for the KRIS/GIS project, while the NCRWQCB will be responsible for managing the program in coordination with California Resources Agency watershed assessment methods and needs. By filling the gaps in drainage coverage and developing a unified platform for data review, analysis, and manipulation, consistent with other similar projects in Northern California, the North Bay KRIS/GIS will facilitate salmon and steelhead conservation and recovery planning by NOAA Fisheries and CDFG.

4.5.1.5 Restoration Project Database

SCWA is funding a project for the NCRWQCB to develop a database of potential restoration projects in the Russian River watershed. The database is intended to identify specific projects that will enhance the quality of surface waters within the Russian River watershed to benefit listed and unlisted aquatic and terrestrial species.

In cooperation with local agencies, watershed groups, and stakeholders, including CDFG and the Sotoyome Resource Conservation District, the NCRWQCB determines what mitigation, enhancement, or water quality improvement projects are currently being proposed, are under development, or may be needed to increase recovery and protection of the listed and unlisted species in the Russian River watershed. The NCRWQCB inventories and prioritizes these projects in the *Russian River Watershed Restoration Potential Projects Database* for use by local agencies in determining which projects will protect and speed the species' recovery. Development of this database will aid in coordinating project implementation on a watershed or sub-watershed basis, with the goal of improving water quality and habitat conditions in the most timely and efficient manner. NCRWQCB began development of this database in 1999. The database is intended to be functional and updateable for all users.

4.5.1.6 Invasive Plant Species Management

SCWA has funded studies to evaluate the status and control of invasive plant species in the Russian River watershed. These studies will inform other projects and assist with watershed-level planning efforts to control invasive species. In 1998, SCWA funded the initial phases of research into the spread of these exotics. To expand the research, Circuit Rider Productions Inc. and Sonoma State University will continue ongoing experiments and initiate new investigations. SCWA's Invasive Plants Species study has focused on the exotic plant *Arundo donax* (giant reed), which has been spreading rapidly and is threatening the integrity of the Russian River's native riparian community.

When non-native plant species replace native species, the riparian ecosystem that salmonids depend on can be altered. The purpose of the Invasive Plant Species Study is to: 1) determine the influence of the exotic plant species, *Arundo donax*, on the composition of native riparian vegetation and invertebrates along the Russian River; 2) evaluate the response of aquatic insects to native and non-native plant litter deposited in the mainstem and tributaries; 3) identify the most effective methods for eradicating *Arundo*; 4) develop techniques for restoring vegetation in previously invaded riparian areas; 5) map the distribution of *Arundo* in tributary streams; and 6) educate the public about *Arundo* and coordinate and train volunteers for *Arundo* removal and follow-up restoration projects. SCWA contributed $58,000 in labor and materials to this project.

The control and restoration of areas invaded by *Arundo* were the focus of two projects. In the Alexander Valley, *Arundo* was removed from test plots by herbicide and mechanical methods, and these experimental trials indicate that herbicide and tarping are highly effective control methods. The recovery of exotic and native plants within the plots was evaluated and showed that removal of *Arundo* allows rapid natural regeneration of invaded sites. In another location, the success of revegetation techniques after *Arundo* removal was evaluated. Exotic plant species influence on invertebrate population abundance was assessed. A UC Berkeley study found a significant preference by aquatic insects for native vegetation, suggesting the food chain for higher animals is altered in *Arundo*-dominated areas.

In 1998, SCWA funded Circuit Rider Productions Inc. efforts to map the extent of *Arundo* along the mainstem Russian River. The 1999 project extended the mapping effort to the Russian River tributaries. The extent of the *Arundo* infestation was delineated using standard aerial photographs and ground surveys. Information collected during these surveys were entered into a computer database (ArcView GIS software) to generate high-quality maps illustrating the extent of *Arundo* along salmonid-bearing tributaries. This basin-wide mapping and GIS program was completed in fall 2001. The program will track *Arundo* populations, prioritize sites for restoration, and monitor project success. Circuit Rider Productions Inc. has provided workshops and technical sessions to local communities, landowners, and environmental groups on appropriate techniques for restoring native riparian habitat in areas where *Arundo* has been removed.

Since 2001, SCWA has funded Sonoma State University's Department of Environmental Studies and Planning to offer a new course in native plant propagation. Copeland Creek and other salmonid bearing streams in the southern Russian River watershed have substantial reaches with canopy that is either missing altogether or substantially sparser, shorter and more dominated by exotics than is optimal for the instream requirements of anadromous fish. Restoration of habitat for steelhead and other native fish and wildlife species depends on restoration of a native riparian plant community along these streams. The course provides students with education in the practical aspects of plant propagation and related restoration techniques. Using existing expertise and facilities on the Sonoma State University campus, the course supplies the Copeland Creek watershed and other watersheds in the area with native plant materials, plant storage and propagation services.

SCWA funded Sonoma State University on-the-ground restoration actions and scientific studies that improve our understanding of how invasive plan species spread. Moderately-sized (30 x 200 meters) plots of the invasive Tree of Heaven (*Ailanthus altissima)* and sweet cherry (*Prunus avium*) on Copeland Creek were eliminated and the areas were restored with native trees. Invaded and non-invaded creek sections were studied to assess effects of these nonnative species on steelhead habitat quality.

4.5.1.7 Federal and State Recovery Planning

The ESA requires development of a recovery plan for listed species. NOAA Fisheries is charged with developing a recovery plan for the Northern California Recovery domain. In north-central California, NOAA Fisheries, CDFG, and local agencies collaborate to provide NOAA Fisheries with support and assistance in fulfilling federal obligations to develop recovery plans. SCWA is providing staff support for the development of an MOU for this effort and is ready to assist as necessary.

CDFG conducts recovery planning for the state coho salmon listing under the California ESA. The State of California initiated a recovery planning process for coho salmon north of San Francisco Bay. SCWA is providing financial and staff support for this effort. SCWA provides support to the State of California to provide a facilitator, technical assistance, and resource economic evaluation. The General Manager of SCWA also sits on the Recovery Team. CDFG completed a Recovery Strategy for California Coho Salmon in 2004 (CDFG 2004). SCWA is providing support to CDFG, the Bodega Marine Lab (BML), and other agencies and organizations in developing a framework for state recovery planning efforts that will facilitate and complement the federal recovery planning effort. SCWA provides technical support to other stakeholders in the development of the strategy, including peer review, additional genetics analysis, evaluation of ocean conditions, and assisting in the development of the guidelines for the recovery strategy.

4.5.2 Riparian and Aquatic Habitat Protection, Restoration, and Enhancement

SCWA began implementation of the FEP in 1996. Since 1996, SCWA has granted funds to various entities each year to provide habitat restoration and research on listed fish species in the Russian River watershed.

In addition to the FEP projects, SCWA has provided funding and staff for research that will facilitate restoration and protection of listed fish species in the Russian River. An important example is SCWA's funding of a project for BML to conduct genetic studies of tissue samples from coho salmon captured in the Russian River watershed. These studies have been used to identify the closest relation of the Russian River salmonids to known population stocks of coho and Chinook salmon. They are being used to help design the coho salmon captive broodstock program at the DCFH. These studies may also be used for genetic analyses of adult salmonids returning to the hatcheries at Warm Springs Dam and Coyote Valley Dam.

SCWA has provided funding and production support for the publication and distribution of a native riparian plant handbook to assist landowners, schools, and community groups with native plant revegetation projects within the Russian River watershed. These efforts reduce streambank erosion and reduce the risk of exotic, invasive plant species being introduced to the riparian habitat. SCWA has provided staff and materials to conduct parcel ownership research in the Russian River watershed. CDFG and SCWA staff will use this landowner contact information to gain stream access for habitat surveys and water quality data collection.

Several specific projects designed to benefit coho salmon, steelhead, and Chinook salmon are described below. In addition to these specific projects, SCWA has funded and/or implemented numerous projects that indirectly benefit coho salmon, steelhead, and Chinook salmon. For example, SCWA has provided funding, staff, and equipment for ongoing clean-up efforts on the Russian River and its tributaries. Those efforts have resulted in the removal of garbage and other materials that could have degraded water quality and habitat quality. These clean-up efforts have also increased community participation in restoration of the Russian River.

A Contingency Fund has been established to provide a source of expertise and materials for small projects not included in the current FEP. There are a large variety of small non-profit groups implementing effective fishery restoration projects in Sonoma County. This fund allows SCWA to provide assistance on a relatively short time frame. The cost of most of these projects is low. For example, SCWA provided $4,535 to fund a 5-year program to teach elementary students about steelhead lifecycle and habitat needs. SCWA funded a restoration project that enhanced 2,500 feet of Austin Creek by installing five boulder wing deflectors, seven log/root wad structures, three willow baffles, and native plants. SCWA funded revision and reprinting of Circuit Rider Productions Inc.'s *Riparian Habitat Guide*.

4.5.2.1 Stream Habitat Surveys

Stream habitat surveys have been conducted in cooperation with CDFG each year of the FEP since 1996, and are intended to assess the habitat conditions of streams that are potentially viable for salmonid production. The goal for this project is to conduct habitat surveys on every stream within the Russian River watershed. All data gathered are entered into CDFG's computer program to prioritize stream restoration projects. These data are available for integration into the KRIS/GIS database. SCWA has allocated staff and materials for this project.

4.5.2.2 Temperature Data Collection

Water temperature monitoring has been conducted each year of the FEP since 1996 to identify streams that provide suitable summer thermal conditions for salmonid juvenile rearing. Because environmental conditions vary annually, an accurate depiction of stream temperature requires data collection in multiple years. Data loggers (i.e., equipment to monitor and record water quality measurements at specific intervals) are removed annually from each stream during the fall and deployed again the following spring. Temperature data have been collected in the Mark West, Maacama, Austin, East Austin, Santa Rosa, Dutch Bill, Hulbert, Dry, Brush, Matanzas, and Big Sulphur creek watersheds. SCWA has allocated staff and equipment for this project. For example, SCWA installed approximately 50 water temperature data loggers in spring 2001. Water temperature data were also collected in the summer and fall of 2002 during a steelhead distribution study (Cook 2003a).

In 2000, SCWA began coordinating its temperature monitoring efforts with the NCRWQCB and other entities, conducting water quality monitoring in the Russian River watershed, including the City of Santa Rosa and Mendocino County. These groups met several times to coordinate placement of temperature monitoring equipment, standardization of techniques, sharing of equipment, and exchange of information. Mendocino County compiles all of the temperature data into a single database. This coordination will allow for more effective monitoring of temperatures in the basin by applying the collective efforts in a more efficient manner, as well as allowing for better comparison of results through standardization of techniques and reporting formats.

4.5.2.3 Water Quality Sampling

This project includes collecting and identifying invertebrates from several streams in the Russian River watershed and analyzing the samples as indicators of water quality. Analysis of the data has entailed sampling of reference streams identified by CDFG for a minimum of 2 years to establish a baseline reference condition. Other streams sampled are compared to those reference streams to determine relative water quality status. This project has been implemented each year since 1996. SCWA contributes staff and materials for the project. Additionally, SCWA provided funding for analysis of samples. Streams assessed include Austin Creek tributaries, Maacama Creek tributaries, the Russian River mainstem, and Mark West, Santa Rosa, Green Valley, Mill, Ackerman, Robinson, Dutch Bill, Hulbert, Fife, Franz, Porter, and Redwood creeks.

4.5.2.4 Russian River Basin Coho Salmon and Steelhead Population Monitoring

Coho salmon and steelhead populations in the Russian River basin have decreased over the last 100 years. However, comprehensive population surveys have never been conducted in the basin, making it difficult to document the decline or accurately track recent population trends. In conjunction with NOAA Fisheries and CDFG, SCWA is planning a basin-wide monitoring program to determine long-term trends in salmonid abundance. Streams throughout the watershed would be sampled annually using a variety of methods including direct observation (snorkeling), trapping, and electrofishing. While the program would generate indices of abundance for all salmonid lifestages (e.g., juveniles, smolts, and adults), SCWA would focus primarily on obtaining population estimates for juveniles during late summer and fall. Consistent environmental conditions during this portion of the year allow access to a large number of sites and increase the repeatability of annual surveys.

SCWA funded a project to develop a study plan for the population monitoring project. Following the second year of the pilot study, SCWA adopted a final plan in consultation with NOAA Fisheries and CDFG and has completed the first 3 years of a pilot study to evaluate methods and sampling sites in the field. During the second year of this project, electrofishing and/or snorkel surveys were conducted in three tributaries of the Russian River, including 68 sites in Santa Rosa Creek, 66 sites in Mark West Creek, 20 sites in Millington Creek, and 122 sites in Sheephouse Creek. Protocols developed after the first 2 years of the study would be used for this project as well as other FEP projects requiring fish surveys. The focus of this project is currently being reevaluated and the objectives of future population studies will likely change to meet the needs of SCWA and cooperating entities.

4.5.2.5 Green Valley Creek Spawning Substrate Characterization

SCWA funded a joint effort between O'Connor Environmental, Inc. and Circuit Riders Productions, Inc. to characterize salmonid spawning substrate and perform a fluvial geomorphic analysis in Green Valley Creek. This investigation collected sediment samples from pool tail outs using McNeil samplers and from adjacent gravel bars to determine sediment size distributions, conducted habitat surveys according to CDFG protocols for habitat units immediately adjacent to sampling sites, measured surface sediment size distributions, and surveyed local channel geometry. The data were analyzed to describe spawning habitat in terms of overall size composition and proportions of fine sediment and the data were synthesized to examine the relationship between local channel conditions and sediment size distributions.

4.5.2.6 Russian River Coho Recovery Stream Monitoring Instrumentation

SCWA funded the University of California, Cooperative Extension, to purchase and install stream stage and stream temperature monitoring equipment to conduct water quality and water quality monitoring as part of the Russian River Coho Salmon Recovery Program's Comprehensive Long-term Monitoring. This project will install instruments in six streams to be stocked with coho salmon and three control streams. The data are critical to determine the success of the recovery program. Stream stage data will be used to determine the timing and intensity of stream flow. Stream temperature data will be used to understand the variability of temperature within and between individual streams.

4.5.2.7 Russian River Habitat Mapping Plan

SCWA funded the E-centers' Mendocino Fisheries Program to map the locations, depths, areas and temperatures of pools in the upper Russian River, map and measure historic salmonid spawning sites, and map the locations of and describe erosion sites. The study encompassed approximately 35 miles of mainstem channel from the east and west forks down to Cloverdale. E-center staff used kayaks to float the study area. Pools were described by a single longitudinal pass using an electronic depth measuring unit along the thalweg. The heads and tails of pools were mapped with GPS units and channel widths were measured with a range finder. Outflow from Coyote Valley Dam was recorded each day. The location and length of spawning riffles and eroding areas were also mapped using hand-held GPS units. Water temperatures were recorded in all mapped units to determine if thermal stratification was occurring in the deeper units.

4.5.2.8 Instream Habitat Improvements

SCWA has funded and/or implemented projects since 1996 to improve habitat in stream channels. Mill, Austin, Turtle, Felta, Green Valley, and Dutch Bill creeks were identified as candidates for instream habitat improvements. Instream habitat structures that have been placed consisted of large woody debris, such as rootwads, that provide protective cover from predators and that promote development of pools. Sites lacking in riparian cover have been planted with trees. A section of Big Austin Creek was reconstructed to convert a braided, intermittent channel to a single thread, perennial stream, with 13,000 square feet of reconstructed spawning area. Additionally, bank stabilization and riparian planting were implemented along Big Austin Creek (see Section 4.5.2.15). SCWA provided matching funds and staff support for these projects. SCWA also provided partial funding to install seven large woody debris structures in six pools along Dutch Bill Creek that provide habitat for coho salmon.

Green Valley Creek is one of the few tributaries in the Russian River watershed that still supports a self-sustaining, although diminished, population of naturally-spawning coho salmon. Surveys conducted by CDFG showed that Green Valley Creek lacked pool habitat and cover. Completed in 2002, the Green Valley Creek Restoration (Site 1) project increased the amount of pool habitat in the creek by installing four large instream woody debris structures. These structures were in good condition after the winter floodwaters of 2000/2001 and a CDFG biologist observed coho salmon at the enhanced pool. The endangered California freshwater shrimp also occurs at the pool. A restoration project at the Green Valley Creek Restoration (Site 2) included recontouring an eroded bank, installing a willow mattress, and planting 35 native riparian trees, thereby stabilizing and restoring 30 feet of eroding bank. This project was completed in 2002. The Green Valley Creek Restoration (Site 3) project stabilized an eroding bank by constructing a small berm at the base of a drainage swale and recontouring the bank to stabilize the soil. Two wood structures were installed in the creek to enhance pool habitat for salmonids. Approximately five native riparian plants were planted in fall 2001. Both of these projects reduced sediment input to the creek. These two projects were partially funded by SCWA.

4.5.2.9 Riparian Restoration

SCWA has funded and/or implemented projects on Howell and Turtle creeks to exclude livestock from the riparian zone adjacent to the stream, and to replant degraded areas with native vegetation. These projects allow riparian vegetation to reestablish, stabilize streambanks, and decrease animal waste entering the stream. SCWA has provided funding, staff, and materials for these projects. In areas where vegetation has been removed, native trees will be planted to provide vegetative cover for wildlife, and shade and structure for aquatic biota.

The Lytton Creek Riparian Restoration and Education project restored 15 acres of native riparian habitat along a salmonid-bearing tributary to the Russian River. The project restored a degraded riparian zone and converted 4 acres of vineyard back to riparian habitat. In the winter and spring of 2001, 1,200 plants were installed with a 90 percent survival rate in early July of the same year. Restoration effects will be monitored for a 5-year period. The project included an environmental education program that incorporated high school students, landowners, and the community in the planning, design, implementation, and monitoring of the project. This project provided an important opportunity to demonstrate that healthy natural ecosystems can coexist with viable farming practices. Circuit Rider Productions Inc. and Clos du Bois winery implemented the project and SCWA provided $27,936 in matching and in-kind funds.

SCWA provided funding for a study to investigate methods of controlling Pierce's disease through removal of non-native plants that are serving as sharpshooter hosts while maintaining a viable riparian community. The disease attacks cultivated grapes and is transmitted by insects (i.e., sharpshooters). Vegetation on Maacama Creek was removed using hand labor and herbicides. Native trees were planted to provide vegetative cover and to provide habitat for birds and small mammals, as well as to provide shade and recruitment of woody debris into the creek for fish. Removal of targeted riparian understory was completed in 1999 to 2000. Researchers from UC Berkeley conducted insect monitoring for 3 years. Insect trapping found a 50 percent reduction in sharpshooters in riparian-managed areas compared to undisturbed riparian areas. The reduction in sharpshooters was 70 to 99 percent at two other study sites located in Napa Valley. This project demonstrated that selective removal of vegetation can control an insect vector of Pierce's disease while maintaining riparian habitat.

4.5.2.10 Rural Road Erosion Control Project

SCWA provided funding and materials for a project to decrease sediment runoff from 1 mile of steeply graded rural roadway adjacent to Palmer Creek. The project consisted of measures to reshape, grade, and excavate runoff ditches in the existing roadway and resurface it with high-quality crushed blue shale. Undersized culverts were replaced to minimize erosion. A series of rolling dips was graded into the roadbed in an effort to properly drain the road and reduce erosion during heavy rains. In addition, decreasing the sediment load enhanced instream habitat structures on the same stretch of Palmer Creek. The project, also funded by SCWA, was completed in 2001.

4.5.2.11 Hood Mountain Regional Park

This project was implemented to reduce delivery of fine sediment to Santa Rosa Creek from an eroding road adjacent to the stream. The portion of Santa Rosa Creek within Hood Mountain Regional Park provides valuable spawning and rearing habitat for steelhead. During the winter of 1996-97, a landslide on Hood Mountain Trail, adjacent to Santa Rosa Creek, displaced over 300 cubic yards of material. In 1999, the site remained unstable and continued to deliver fine sediment to the stream. SCWA granted FEP funds to Sonoma County Regional Parks in 1998 for the development of engineering plans to stabilize the slide. The project was implemented during the 1999-2000 FEP and provided a comprehensive repair to the cut slope, modified the road surface, and filled gullies.

From 1998 through 2001, SCWA provided staff support, materials, and funding for other components of the Hood Mountain project, including: regrading a road crossing and adding rock baffles to improve fish passage; removal of litter (e.g., chain link fence, 55-gallon drums); and development of a water quality monitoring program to be run by LandPaths staff and local high school students.

4.5.2.12 Brush Creek

This project was designed to maintain the flood conveyance capacity of Brush Creek while improving aquatic and riparian habitats. The completed project enhances available habitat for steelhead and other native fish, amphibians, songbirds, and small mammals along Brush Creek. Brush Creek previously underwent channel modifications to allow conveyance of 100-year flow events and provide flood protection for local homeowners. The project widened the cross-sectional area of Brush Creek to permit the stream to both convey streamflow during a 100-year flood event and provide the area necessary to increase habitat diversity along 1,200 lf of the stream. Overall, approximately 4,500 cubic yards of material was removed from the streambed and banks. After the streambed and banks were graded, a series of restoration and enhancement activities were instituted to provide aquatic and riparian habitat throughout the project area. A meandering low-flow channel was constructed in the streambed. Instream structures such as weirs, deflectors, and suitable substrate material were placed in the river to promote the development of pool and riffle habitats, as well as providing bank stability. Streambanks denuded of vegetation during the sediment removal and grading phase of the project were replanted with native vegetation. SCWA contributed $40,000 of funding to the $287,000 project.

4.5.2.13 Copeland Creek

This project involved construction of cattle enclosure and monument fencing, recontouring heavily eroded streambanks, and revegetation with native riparian species on Copeland Creek. The project site is located on approximately 6,000 feet of Copeland Creek between Roberts/Pressley Road and Petaluma Hill Road. Historically, the project site has been grazed by cattle and horses. Grazing pressures limited vegetation establishment to non-native grasses and forbs, with tree cover limited to a stand of non-native Eucalyptus, some scattered oaks (*Quercus* sp.), and California buckeye (*Aesculus californicus*). Numerous cattle paths crossed the channel, and trampling exacerbated erosion of the banks. Restoration of this section of stream decreased sediment load and improved fish habitat. Fencing was installed to prevent livestock access to the riparian zone. Banks were recontoured to a more stable profile. Riparian vegetation was reestablished along the streambanks to provide stability and shade. This project began in 1999 and implementation was phased over several years. Restoration of the final 1,000 feet of degraded creek was completed in 2003. Monitoring of fish, wildlife, and habitat began in winter 2001 and is scheduled for at least 5 years. SCWA provided staff support, materials, and funding for this project.

4.5.2.14 Howell Creek Livestock Exclusion Fencing and Riparian Enhancement

This project excludes cattle from the riparian zone along 4,000 feet of Howell Creek, a tributary of the Russian River, in Mendocino County. A 1998 stream inventory conducted by CDFG indicated that riparian vegetation and stream channel conditions were degraded due to unrestricted cattle grazing in this reach of Howell Creek. This section of stream provided only marginal habitat for steelhead. Healthy riparian vegetation is necessary to improve the condition of the streambanks and bed in this reach. Barbed wire fence was installed and off-stream water sources were developed to eliminate the intrusion of cattle into the riparian zone. Native riparian vegetation was planted in the project site to facilitate recovery. SCWA is providing $14,232 in funding for this project.

4.5.2.15 Big Austin Creek

This project reconstructed 1,300 feet of braided, intermittent channel to a single-thread channel, perennial stream with 13,000 square feet of reconstructed spawning area. The project also included bank stabilization and riparian vegetation planting along sections of the stream channel. Prior to the project, a series of shifting channels flowed through an area known as “King’s Flat.” Large amounts of bedload from old mining tailings located upstream of the project area caused excessive aggradation, resulting in a braided multichannel stream. By restoring the stream to a single channel, fish habitat is greatly improved. Stream sections with highly eroded banks were stabilized with rock, rootwads, and live trees. Riparian vegetation was reestablished along the banks to increase cover and help reduce water temperature. Work completed under the 1997 to 1998 FEP Plan included bank stabilization, placement of instream cover, and construction of willow baffles. Work conducted under the 1999 to 2000 FEP Plan included additional stream bank stabilization and riparian vegetation planting. The site has stabilized naturally and a weir originally planned for the site is not needed. Restoration is considered complete and monitoring is scheduled through 2003.

4.5.2.16 Russell Irrigation Site on Turtle Creek

The purpose of this project was to facilitate development of a mature riparian forest, stable streambanks, and improved aquatic and terrestrial habitats. This was accomplished through providing an alternative drinking source for livestock that previously used the stream as a watering source. The landowner for this site previously participated in a voluntary fencing project to exclude the cattle from Turtle Creek. To provide the alternative drinking source for the livestock, a well was removed and repaired, and 2,100 feet of pipe were installed to deliver the water to the cattle. SCWA provided the funding for this project.

4.5.2.17 McNab Creek Restoration Project

SCWA funded the E-centers’ Mendocino Fisheries Program to conduct stream restoration efforts on McNab Creek in Mendocino County. The project consisted of stabilizing stream banks and improving the quality of fish habitat at thirteen sites on McNab Creek. At five sites stream banks were stabilized using bioengineering techniques and at nine sites instream structures such as cross vane weirs and log structures were installed to improve habitat quality. This project was completed in 2001.

4.5.2.18 Mumford Dam Fish Passage and Riparian Restoration

Mumford Dam is a privately-owned, medium-size diversion dam (approximately 60 feet wide and 8 feet high) located on the west branch of the Russian River near the town of Redwood Valley. The dam is used to divert flows for vineyard irrigation and frost protection.

Since the dam’s construction in the early 1900s, the streambed below the dam has down-cut between 8 to 15 feet. This down-cutting eliminated fish passage over the structure, restricting access to approximately 45 miles of spawning habitat. In addition, down-cutting caused massive erosion and bank failure for approximately 600 feet below the dam. This restoration project improves fish passage over Mumford Dam and improves streambank stability and riparian habitat near the dam. The project involved recontouring the streambanks to a more stable profile, constructing a series of weirs to facilitate fish passage, and revegetation with native plants. The dam owner also upgraded the diversion facilities to comply with NOAA Fisheries fish screening criteria. SCWA has provided more than $700,000 in funding for this project and has obtained approximately $500,00 0 in grant monies for this project. SCWA assisted the Simon Partnership (landowners) with engineering design plans, conducted botanical, fish, and wildlife surveys needed for the environmental permitting, and acquired needed permits. Project construction was implemented in the summer of 2003, and revegetation was implemented in the fall of 2003.

4.5.2.19 Crocker Creek Dam

Crocker Creek Dam was located near Asti. When Crocker Creek Dam failed, the impact to Crocker Creek was significant. A large sediment load was released downstream from behind the dam and the creek upstream of the dam experienced major erosion and collapsing banks. While the elevation of the base of the dam was lower than the previous top of the dam, the structure and debris pile posed an impassable barrier to anadromous salmonids. A significant amount of work was done at this site.

The objective of the Crocker Creek Dam removal project was to restore anadromous fish, primarily steelhead, access to the Crocker Creek watershed while stabilizing streambanks in the vicinity of the dam. The project included removal of the remaining dam infrastructure, recontouring the streambanks to a more stabile profile, constructing a series of weirs to facilitate fish passage, and revegetating with native plants.

4.5.2.20 Laguna de Santa Rosa

USACE is conducting a feasibility study to investigate the extent and causes of sedimentation in the Laguna de Santa Rosa ("Laguna"). The Laguna area is a large, gently sloping basin with natural flood retention capability and historic wetland attributes. Historically, it served as a major storm retention basin during periods of flooding. Human development has modified hydraulic and hydrologic conditions in the surrounding area and may be accelerating habitat changes in the Laguna. Siltation from municipal development in the surrounding area and from certain agricultural practices may be reducing the Laguna's attributes and flood-retention capability.

The Laguna drains a basin of 250 square miles (160,000 acres) that includes the adjacent cities of Cotati, Rohnert Park, Santa Rosa, and Sebastopol. The Laguna transports rainfall runoff from the watershed to the Russian River, and as the water surface elevation in the Russian River rises with increasing flows, water flows back into the Laguna from the Russian River. The Laguna is considered to be an important factor in lowering the water surface elevation in the lower Russian River floodplain.

The results of the initial sedimentation studies will determine which, if any, alternatives are investigated for the possibility of management and restoration measures. To reduce the negative effects of sedimentation on the Laguna's flood control capacity and habitat, such measures could include:

- Watershed management. This could involve identifying sediment reduction alternatives; conducting a topographic survey to compare past data and as a baseline for future studies; inventorying stream channels; analyzing air photos; and using historic and current information to determine local sources of sediment affecting the Laguna.

- Channel restoration. This could involve identifying and characterizing flood control channels within the Laguna; identifying and evaluating structural flood detention alternatives; and identifying and evaluating flood protection.

- Habitat restoration. This could involve identifying and characterizing opportunities to restore historic wetlands for optimum diversity and long-term sustainability.

4.5.2.21 Santa Rosa Creek

The City of Santa Rosa is undertaking a project to restore Santa Rosa Creek by returning the channelized creek reaches to a more natural geomorphic and ecological form and function and improving water quality, while maintaining existing levels of flood protection. The USACE, SCWA, and Sonoma County are assisting the City of Santa Rosa with project development or implementation. The restoration is also intended to benefit steelhead and other aquatic life.

Initially, the City of Santa Rosa (the nonfederal sponsor) requested that the USACE conduct an investigation to determine whether there was a federal interest in an ecosystem restoration project along the creek**.** A 1997 Reconnaissance Report that investigated the Russian River and tributaries concluded it was likely that an ecosystem restoration project would be in the federal interest. USACE and the City of Santa Rosa developed a project study plan and subsequently executed a cost-sharing agreement to initiate the current Santa Rosa Creek Ecosystem Restoration Feasibility Study.

During the initial phase of the study, there was uncertainty about whether the existing flood-control project had adequate capacity for a 100-year-flood event due to floodplain development and environmental changes in local conditions since the project was constructed in the early 1960s. A draft hydrologic analysis, conducted by USACE in August 2002, concluded that improved and unimproved channels within the watershed would experience flows during a 100-year-storm event significantly greater than anticipated by the original design documents for those facilities. USACE determined that flood-damage reduction was an appropriate purpose under the existing authorization for the Feasibility Study (i.e., the Water Resources Development Act of 1996). Thus, additional tasks were identified and incorporated into the study, now the Santa Rosa Creek Ecosystem Restoration Feasibility Study.

The Santa Rosa Creek Master Plan was signed on September 21, 1993 by the City of Santa Rosa, the County of Sonoma, and SCWA (Santa Rosa, City of, County of Sonoma, Sonoma County Water Agency 1993). In the City of Santa Rosa Master Plan, the 12.8-mile-long project has been divided into seven reaches, distinguished by vegetation, hydrology, adjacent land use, ownership, channel morphology, and access. Reaches A and B, which are between Highway 12 near Los Alamos Road and E Street, are characterized as natural channel. The vegetation represents a mature, native riparian community. This area is in private property ownership with limited access. Commercial, residential, and undeveloped land uses are located adjacent to the creek. Reaches C, D, and E, are between E Street and Piner Creek west of Fulton Road. They are characterized by a relatively steep, trapezoidal-shaped channel with grouted rock in Reach C and riprap in Reaches D and E. There is very little riparian vegetation. SCWA owns the two maintenance roads on either side. Adjacent land use is commercial, residential, and industrial. The Rural Reaches F and G are between Piner Creek and the Laguna. These reaches are characterized by a wider and shallower channel with more sediment bars, less riprap (none in Reach G), and some riparian vegetation. There are levees in Reach F and maintenance roads along both sides of the creek in both reaches. The adjacent land use is agriculture and floodplain. The boundaries of the proposed restoration project include part of Reach C (Pierson Street to Dutten Street) and all of Reach D through Reach G. No action is proposed for Reaches A or B.

The project is currently in the planning and permitting phase. Several alternatives are being considered, which are discussed below. The selected alternatives will be implemented in the project area. The action alternatives include restoring habitat and improving water quality by implementing one or more of the following restoration types in the various reaches of Santa Rosa Creek (Santa Rosa, City of, County of Sonoma, Sonoma County Water Agency 1993):

> *Type 1 Channel Restoration:* Enlarge channel capacity by removing existing grouted riprap, replacing the southern bank with a steeper, engineered wall system that allows for vegetative growth, and stepping the north bank with a series of retaining walls that allow for multiple use, and pedestrian and maintenance paths. A soft, naturalized creek bottom will be vegetated with native riparian grasses, sedges, and shrubs. This restoration measure is proposed for sections of Santa Rosa Creek between Santa Rosa Avenue and Pierson Street.
>
> *Type 2 Channel Restoration:* Enlarge the channel capacity by removing the existing riprap, laying back the southern bank to a more stable angle, and terracing the northern bank to allow for path installation. The newly constructed channel will be vegetated using native riparian species. The creek bottom will provide a soft, meandering low-flow channel, which will be shaded and feature rocks and anchored logs for fish habitat. This restoration measure is proposed for sections of Santa Rosa Creek between Pierson Street and Piner Creek.
>
> *Type 3 Channel Restoration:* Enlarge channel capacity and expand the existing cross-sectional area of the creek by removing existing riprap, laying back one bank, and excavating the other bank to create vegetated terraces on which paths would be placed. The entire creek channel will be revegetated with native riparian

plant materials. This restoration measure is proposed for limited sections of Santa Rosa Creek between Stony Point Road and Piner Creek.

Type 4 Channel Restoration: Increase the channel width by relocating one or both levees away from the creek a total of not more than 100 feet. The creek channel would be re-contoured to create a naturalized meander pattern with riparian plantings throughout. This restoration measure is proposed for sections of Santa Rosa Creek between Piner Creek and Willowside Road.

Type 5 Channel Restoration: The area of riparian vegetation would be expanded by 100 feet or less between Willowside Road and Laguna de Santa Rosa to enhance the riparian vegetation and to allow the development of a meandering low-flow channel.

In Measures 1 through 5, rocks would be placed in the creek to create pools, riffles, and runs, and define the low-flow channel. In addition, anchored logs with root wads exposed to the creek will be installed. These features will enhance the structural diversity of the channel bottom and improve fish habitat. SCWA is currently implementing some of the components in the Santa Rosa Master Plan.

4.5.2.22 Dry Creek

Gravels used by coho salmon for spawning are smaller than those used by steelhead or Chinook salmon (Kondolf and Wolman 1993). As discussed in *Interim Report 1*, the high flows in Dry Creek may more readily transport coho salmon gravels out of the upper reach (ENTRIX, Inc. 2000a).

SCWA would construct habitat improvement structures using boulders and redwood or fir trees at suitable locations in Dry Creek to increase habitat complexity and available cover, and provide areas that hold gravels used by coho salmon for spawning. Structures would have to be quite large to remain in place and be effective at trapping these gravels. The structures would typically consist of three or four, 3- to 5-ton rocks and a tree with attached limbs and root ball. Individual trees would be at least 18 inches in diameter and 35 to 40 feet long. The structure would resemble a grounded sweeper and debris pile along the channel margin. Debris clusters would be anchored in place by burying the downstream end of the tree and placing a large rock on top of the back-filled excavation. Two large boulders would hold the root ball in place. These structures may require periodic maintenance/modification of the debris to maintain its effectiveness. Initially, root wads or other structures would be placed at intervals of 500 feet, on average, providing approximately 150 structures along a 14-mile length of channel. These would not be placed at even intervals, but rather clustered in areas where geomorphic conditions and access afford the best opportunities.

Large woody debris or other structures placed in the stream channel may reduce channel capacity and increase the risk of flooding and/or bank erosion. Large woody debris may slow or alter currents in a way that could increase the potential for flooding of adjacent land. These instream structures could, in some cases, redirect flows to streambanks and encourage bank erosion. Therefore, placement of large woody debris would require establishment of an expanded riparian zone for flood protection and education of the public regarding the benefits of this action. If structures placed in the stream become mobile, they may cause flooding due to obstruction of flows. The effectiveness of this action is related to the number of locations where it can be implemented. While a larger number of structures would promise greater habitat gains, restricted stream access and the need to obtain permission from landowners may constrain the number of sites where structures could be placed.

Purchase of conservation easements would be required to fully implement some of these actions.

4.5.2.23 Gold Ridge Stewardship Program

The Gold Ridge Stewardship Program enhances fisheries habitat and water quality through coordination of watershed restoration and stewardship efforts. The Gold Ridge Resource Conservation District promotes the formation of watershed groups for community members through education, outreach, and identifying priority watershed issues. SCWA provided matching and in-kind funds. In 2000-2001 the stewardship program published two newsletters and hosted a rural roads workshop. The rural roads workshop was presented by Pacific Coast Watershed Associates and discussed proper installation and maintenance of private dirt roads to minimize erosion and runoff into streams.

The Gold Ridge Resource Conservation District organized clean-ups in the Green Valley and Dutch Bill Creek watersheds with local watershed groups, schools, and other local groups and agencies. The purpose of the Gold Ridge Creek clean-ups is to minimize pollution and obstructions to fish passage, improve creek aesthetics, and distribute educational materials. The clean-ups are supplemented by the distribution of educational materials to landowners regarding the effects of pollution on fisheries and water quality.

4.5.2.24 Riverfront Park Reclamation

SCWA and the Sonoma County Agricultural Preservation and Open Space District ("Open Space District") together purchased property from Hanson Aggregates Mid-Pacific, Inc. The 304.62-acre property will be used for preservation of open space, a public park, and for water education purposes. The SCWA Riverfront Park property is located adjacent to the Russian River in north-central Sonoma County at 7821 Eastside Road. Located on the floodplain terrace of the Middle Reach of the Russian River, the property was used for terrace-pit gravel mining (Figure 4-4). Three pits have filled with water and are now referred to as Lake Benoist (67 acres), Lake Wilson (37 acres), and Lake McLaughlin (23 acres). The property also contains a graded area (the McLaughlin Pad), which was the site of gravel processing operations. As part of the mining operations, the topsoil was previously stripped from the McLaughlin Pad and stockpiled on-site for future reclamation purposes.

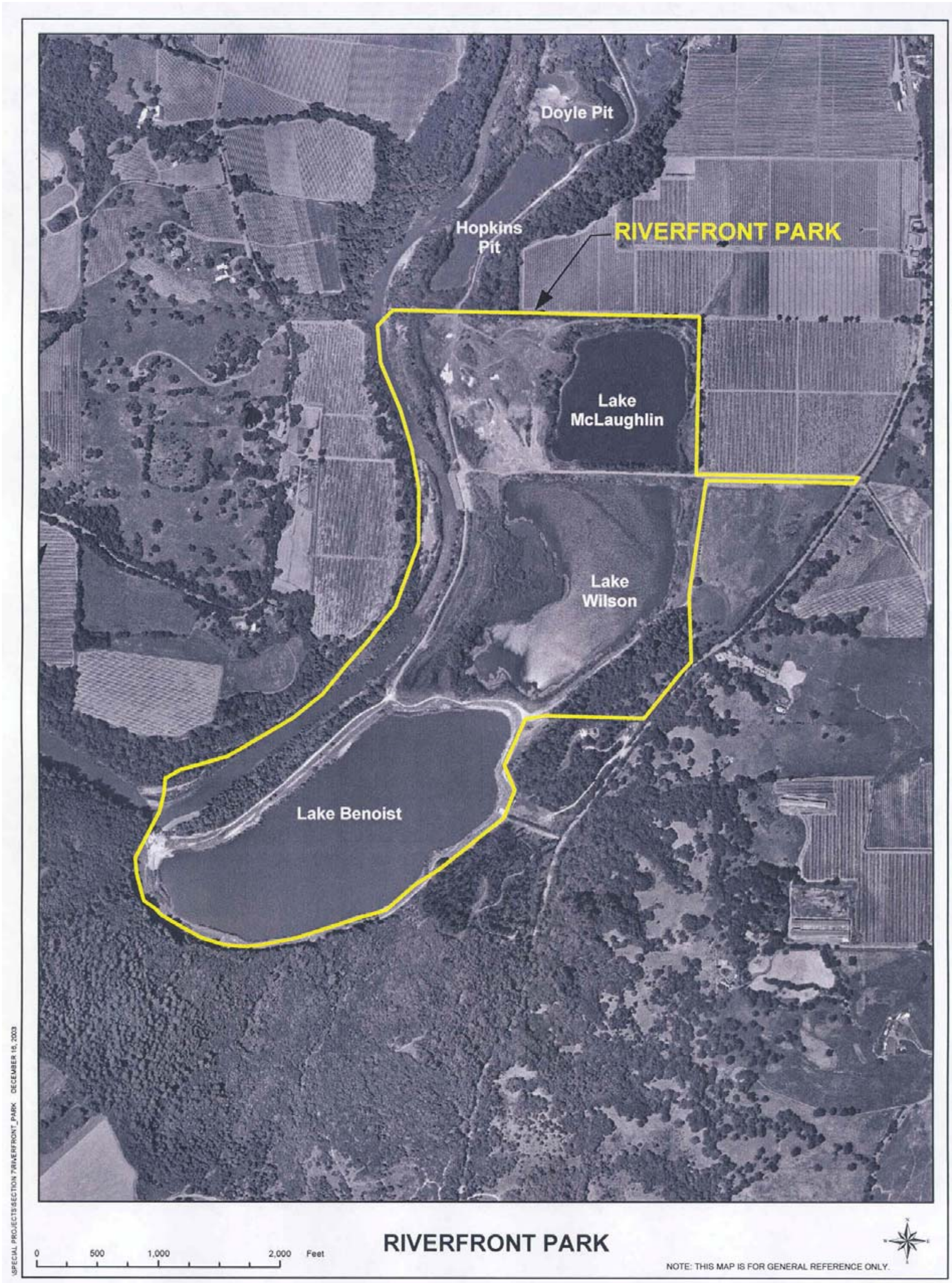


Figure 4-4 Riverfront Park Area Map

There is a potential for salmonids to be entrained in these lakes when water levels recede after high-flow events. This entrainment potential existed before SCWA acquired the property. There are levees on the riverbank next to the property, but flood water can flow through an opening in the riverbank at the Doyle Pit located to the north of Lake McLaughlin (Figure 4-4) and flood adjacent property. Flow can enter Lake McLaughlin at several locations through the berm at the north end of the lake. Floodwaters can also flow from the northwest when the river overtops the banks. Water also flows to Lake Benoist through a rock riprap weir at the southern end of the lake, and floodwaters can back up into Lake Wilson and Lake McLaughlin. At high-flood flows, the entire area can be under water.

River water that crests the bank at the Doyle Pit and flows into Lake McLaughlin provides a potential conduit for fish passage. A berm with an average elevation of approximately 71 feet on the north side of the McLaughlin site prevents floodwater from flowing directly into Lake McLaughlin from the north. However, floodwaters, as well as overland flow, can flow through culverts through the berm. Flow from the property to the north (particularly from the terrace at two locations in the vicinity of the Hopkins and Doyle pits) can flow through two 8-foot culverts located on the northeast corner of the lake, and through a 3-foot culvert on the northwest corner of the lake that drains approximately 5 acres of vineyard.

Aerial topography and field inspection show that the two 8-foot culverts drain approximately 23 acres, and the remainder drains through a vineyard swale into the Doyle pit (Murray, Burns, and Kienlen 1999). Water can flow through a low area adjacent to the Doyle Pit located at the northeast corner of Lake McLaughlin. When the terrace near the Hopkins and Doyle pits to the north of Lake McLaughlin reaches a flood stage of 63.5 feet (1.75-year return interval or 28,000 cfs at Healdsburg), flow is directed through two swales toward the McLaughlin culverts.

Floodwater from the river flows through the weir at Lake Benoist. The top of the weir is at an elevation of approximately 53.0 feet, and fish passage can only occur when water flows over it. When Lake Benoist is full, water flows into Lake Wilson over the land bridge between the lakes. An abandoned haul road embankment separates McLaughlin and Wilson lakes. Water flows into Lake McLaughlin when floodwaters overtop the lowest perimeter elevation between the Lake McLaughlin and Lake Wilson banks, which is approximately 60.5 feet (NGVD) at the southwest corner of Lake McLaughlin (1.25-year return interval).

Hydraulic analysis at the site indicates that the riverbank at Lake McLaughlin can be expected to overtop at approximately a 2-year average return interval. The lake and surrounding landscape are completely inundated at an elevation of 71 feet (generally a 10-year-flood event).

When flood flows recede, Lake McLaughlin drains into Lake Wilson. All three lakes eventually drain back to the Russian River through the weir in Lake Benoist and via ground percolation. During the summer, Lake Benoist is the deepest of the three lakes with a depth of over 50 feet.

SCWA is preparing plans for reclamation of the property to return the site back to wildlife habitat consistent with the intent of the site-specific 1995 Master Reclamation Plan. The reclamation work would include surface regrading and replacement of topsoil over the McLaughlin Pad, repair of erosion damage at the two-way spillways between the lakes, construction of the levee closure between McLaughlin and Wilson lakes along the Russian River, and installation of native vegetation to create wildlife habitat on the site. Reclamation work will be coordinated with Sonoma County Regional Parks Department's plans to incorporate initial trails and enhance access to portions of the property. Contract drawings for a reclamation construction project would be prepared in 2004 with construction scheduled for completion by the end of 2004.

4.5.2.25 Best Management Practices for Restoration Projects

BMPs used are site-specific, but, in general, SCWA follows the procedures outlined in the CDFG Fisheries Habitat Restoration Program. With few exceptions, SCWA projects are not built on "live" streams. Most can be constructed during a period when the stream is dry. In most cases, if not all, work in a wet stream channel would require a permit from USACE, and the terms and conditions of that permit would dictate the practices used to minimize effects. For example, on Austin Creek reconstruction of the toe of the bank was necessary, and the BMPs used were those stipulated by the USACE permit. A combination of detention basins, hay bales, and filter fabrics were used, and no sediment problems were identified. On Adobe Creek (not in the Russian River Basin), SCWA built a fish passage (with a series of boulders) in an active stream, and fish rescues were conducted to move as many fish as possible out of the project area.

SCWA strives to avoid any effects to the streams or listed species while implementing restoration projects. Details for specific projects to be constructed have been provided where they are known.

Table 4-8 summarizes information about actions that are part of the proposed actions and, where known, indicates the listed fish species the action is likely to affect. Steelhead are the most abundant species in many of these areas, but as coho or Chinook salmon populations are recovered, use of these streams by these species is likely to increase. All projects listed are likely to improve habitat for spawning, rearing, and migration of listed salmonids. Restoration actions that are part of the proposed actions and have been implemented since the time the MOU was signed represent an improvement to baseline conditions and do not require a take authorization. Actions that require take are projects that will be implemented and may have direct effects on listed species during construction. They are usually projects that require instream work while listed fish species may be present. BMPs to minimize adverse effects are generally outlined during the permitting process.

Table 4-8 Summary of Restoration and Conservation Actions that are Part of the Proposed Actions

The size of the project is the actual length of stream affected. A "+" indicates projects that have effects that may extend well beyond the immediate project area.

Creek	Type of Project	Size of Project	Species Affected[1]
PART OF THE PROPOSED ACTIONS (NO TAKE STATEMENT REQUIRED)			
Instream Habitat Improvements			
Dutch Bill	7 habitat structures	6 pools	Co, St
Mill	14 sets instream habitat structures	~ 2 miles	St
Felta	14 sets instream habitat structures	~ 2 miles	Co, St
Green Valley	Four instream habitat structures		Co, St
Riparian Restoration			
Copeland	Fencing, grading, riparian planting	6,000 ft	St
Copeland	Propagation of native plants and control of invasive non-native plants		St
Green Valley	Erosion control and riparian planting		Co, St
Howell	Fencing	4,000 ft	St
Lytton	Riparian planting with environmental education	14 acres	St
Turtle	Willow walls & mattresses	500 ft	Co, St
Turtle	Irrigation	> 1 mile	Co, St
Felta	Willow walls	3 projects	St
Russell Irrigation site on Turtle Creek	Fencing, cattle removal	> 1 mile	Co, St
Unnamed - Huff property	Willow wall		Co, St
Instream and Riparian Restoration			
Austin	5 boulder wing deflectors, 7 log/root wad structures, 3 willow baffles, native plants	2,500	St
Brush	Streambed and bank regrading, instream structures, revegetation	1,200 ft +	St
Big Austin	Reconstruct channel	1,300 ft	Co, St
Big Austin	13 erosion control/riparian structures – willow baffles, willow wall, slide repair	0.5 mi. +	Co, St
Green Valley	Erosion control, revegetation, two instream habitat structures		Co, St
McNab	5 streambank stabilization sites and 9 instream structure sites		St
Palmer	Instream habitat structures	3,000 ft	St
Santa Rosa Creek	Restore channelized creek to more natural form and function	12.8	St

Table 4-8 Summary of Restoration and Conservation Actions that are Part of the Proposed Actions (Continued)

The size of the project is the actual length of stream affected. A "+" indicates projects that have effects that may extend well beyond the immediate project area.

Creek	Type of Project	Size of Project	Species Affected[1]
PART OF THE PROPOSED ACTIONS (NO TAKE STATEMENT REQUIRED)			
Rural Road Erosion Control			
Palmer	Erosion control, instream structures	1.5 +	Co, St
Santa Rosa (Hood Mt.)	Road and landslide erosion control	100 yds +	Co, St
Fish Passage			
Santa Rosa (Hood Mt.)	Rock weirs at stream crossing	10 miles upstream habitat	Co, St
PROJECTS THAT MAY REQUIRE TAKE AUTHORIZATION			
Instream Habitat Improvements			
Dry Creek	Instream habitat structures	14 miles	St, Co, Ch
Palmer	Instream habitat structures		St
Fish Passage			
Mumford	Engineering design plans, surveys for environmental permitting	50 miles upstream habitat	Co, St

[1]Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

4.5.3 WATER CONSERVATION AND RECYCLED WATER

SCWA has completed a preliminary assessment of urban water reuse to evaluate the feasibility of recycled water projects. The assessment addressed the following elements of water conservation and recycled water use:

- The potential reduction in peak demands on the water supply system that could be realized through the expanded use of tertiary-treated recycled water for irrigation.
- The potential reduction in annual water supply demands from expanded use of tertiary-treated recycled water.
- Order-of-magnitude costs (within 30 percent to 50 percent of actual cost) for construction and operation of recycled water distribution systems in urban areas.

In addition to the preliminary assessment for urban recycled water projects, SCWA is participating in a feasibility analysis of a storage and distribution system for the agricultural use of recycled water from the City of Santa Rosa's Geysers Pipeline. This project would provide recycled water to agricultural users in the northern portion of Sonoma County. The water source is recycled water produced by local wastewater treatment facilities that is in excess of the amount that has been committed to other existing uses.

4.5.3.1 Recycled Water Feasibility Study

Background

SCWA provides a wholesale potable water supply for eight water contractors. The use of recycled water for irrigation in urban areas has the potential to reduce the peak summer demands on SCWA's water supply system. During the peak water demand periods, SCWA's water supply system is currently operating at capacity.

Scope of Assessment

A preliminary assessment of urban reuse was performed, primarily using existing sources of information provided by SCWA's water contractors. SCWA staff compiled and/or generated the necessary project components for the urban reuse projects and applied consistent cost estimates to each project. The cost estimates presented in the assessment represent order-of-magnitude estimates and are intended to allow comparisons of the costs and benefits of the various projects.

Although these cost estimates can be used for preliminary planning purposes, a second-phase feasibility study of potential water reuse would provide a more accurate representation of the necessary components of urban water reuse systems and associated costs. This additional evaluation should include, but not be limited to, computer modeling of the pipeline systems, field surveys of potential pipeline routes, environmental concerns, and evaluation of the existing recycled water irrigation systems.

An assessment of the amount and location of recycled water releases is being developed, but is not available at this time.

Results of Study

Based on the results of a reconnaissance-level study, it appears that the expanded use of recycled water use for irrigation within SCWA's service area could reduce both annual and peak potable water demands from the transmission system. It is estimated that not only could 2,300 AF of water be saved on an annual basis, but also the peak average monthly flow would decrease by approximately 5 mgd.

4.5.3.2 Agricultural Use of Recycled Water in North Sonoma County

SCWA, in cooperation with the U.S. Bureau of Reclamation (USBR), local agricultural water users, and local wastewater agencies, is assessing the feasibility of a storage and distribution system for the agricultural use of recycled water from the City of Santa Rosa's Geyers Pipeline that is more than the amount that has been committed to the Geysers Recharge Project and other existing uses. The proposed project will require the negotiation of agreements between the parties for project design, water delivery, and project financing.

This reuse of recycled water would improve the reliability of the water supply for agricultural purposes in North Sonoma County. The project would also assist SCWA with the development of solutions to address water supply, environmental, and regulatory concerns.

4.6 FISH FACILITY OPERATIONS

Under the proposed project, USACE will continue to fund operations of the DCFH and CVFF fish production facilities. The existing steelhead mitigation program will continue operating as an isolated harvest program, as described in the environmental baseline discussion of Section 3.8, incorporating operational changes that have been implemented due to revisions in CDFG policy and guidelines. A coho salmon integrated recovery program, initiated by CDFG and NOAA Fisheries in 2001, would be conducted at DCFH; this program would replace previous baseline production goals for coho salmon mitigation and enhancement. USACE expanded the DCFH facility in 2003 to accommodate current needs for the coho salmon integrated recovery program, and additional expansion facilities are expected to be built in 2004. No production of Chinook salmon is presently proposed. Results of proposed fisheries monitoring efforts and genetic tissue sampling will be evaluated on a routine basis to determine whether operations should be modified in the future to accommodate supplementation of the wild population for Chinook salmon integrated recovery and/or steelhead integrated harvest programs. Additional structural modifications are proposed at DCFH that would enhance overall function for all programs, regardless of species.

This section begins with a summary of changes in fish facility operations implemented since the end of the environmental baseline period in 1998. The section then presents the goals and objectives of the two proposed fish production programs, followed by a more detailed discussion of each program. Structural modifications that would enhance both programs are discussed separately. Finally, there is a detailed discussion of the two future alternative programs that may be implemented, depending on the results of future monitoring efforts.

4.6.1 AUTHORIZED PROGRAM CHANGES SINCE 1998

In October 1999, a meeting between USACE, CDFG, and NOAA Fisheries established an interim operations plan for the 1999-2000 operating season at DCFH and CVFF. This plan called for the cessation of hatchery production of coho and Chinook salmon in the basin. Steelhead production goals remained unchanged from the original goals. The plan revised the steelhead spawning protocols by specifying that only returning adult hatchery steelhead are to be used for broodstock, and that no wild steelhead are to be used as broodstock. In April 2000, the same agencies agreed to continue the interim operations plan until additional data were available regarding the genetic make-up of fish returning to the hatchery and those found in the wild (Interim Operations Memoranda; J. Christensen, pers. comm. 1999; Joint Hatchery Review Committee 2000).

In May 2001, CDFG submitted a permit application to NOAA Fisheries proposing a pilot program to analyze the effectiveness of a captive broodstock program for coho salmon in the Russian River. NOAA Fisheries issued a BO on August 31, 2001, approving the pilot program under Section 10 (a)(1)(A) of the ESA, which authorized “take” for the purposes of scientific research or enhancement activities. The BO authorizes the pilot program through June 2007, to allow time for adequate implementation and analysis of the enhancement response (NMFS 2001c). The program is an integrated recovery program that will rear juvenile coho salmon collected in the Russian River, use them as broodstock, and then seed progeny into streams in the lower Russian River basin.

4.6.2 Proposed Fish Facility Program Goals

The proposed project for steelhead maintains the existing isolated harvest program, unless the results of future monitoring efforts and genetic analyses of steelhead residing in-river and above the dams indicate that an integrated harvest program would be more appropriate. The proposed project for coho salmon is a continuation of the coho salmon captive broodstock integrated recovery program, to be extended as necessary beyond the current expiration of 2007. No Chinook salmon production is proposed at this time, but a future alternative supplementation program may be implemented if warranted.

Under the proposed project, the existing mitigation and enhancement goals for coho and Chinook salmon will be put on hold for an interim period. The mitigation obligations of USACE for coho salmon, steelhead, and Chinook salmon will be formally revised to provide objectives that are realistic and feasible under current environmental and regulatory conditions. A monitoring program will be implemented to evaluate the effectiveness and performance of hatchery operations and the results of population status monitoring programs conducted by others will be tracked closely. Hatchery operations will incorporate adaptive management practices, which could lead to changes in hatchery production guidelines (such as number of juveniles released, size of juveniles released, or use of wild fish for broodstock) based on monitoring program findings.

Several alternative fish production programs were evaluated in the course of selecting the proposed project options. The results are presented in the Benefit Risk Analysis (BRA) document (FishPro and ENTRIX, Inc. 2002). The BRA considered many factors, including information collected in recent years regarding the status of listed species and habitat conditions throughout the basin, as well as input provided by resource managers, such as NOAA Fisheries and CDFG. The BRA included recommendations for minimum numbers of broodstock to use for each program, as a means of minimizing potential genetic effects on both the hatchery and wild fish populations.

Program goals for the proposed project are summarized in Table 4-9, indicating the program type, release numbers, and minimum numbers of broodstock to use for spawning. More detailed descriptions of the proposed programs are presented in Section 4.6.3 for steelhead and Section 4.6.4 for coho salmon. These descriptions are adapted from the Draft Hatchery and Genetic Management Plans (HGMPs) (FishPro and ENTRIX, Inc. 2003) developed to support this consultation process. The HGMPs provide detailed information on the proposed steelhead and coho salmon programs in a specific format that enables NOAA Fisheries to conduct efficient analyses of the programs.

Table 4-9 Proposed Annual Program Goals for Russian River Hatchery Production

Location / Species	Type of Program[1]	Juvenile Releases	Broodstock Spawning Numbers[2]
Don Clausen Fish Hatchery			
Steelhead	Isolated harvest	300,000 yearling	720
Coho salmon	Integrated recovery	100,000 advanced fingerling	300 - 600
Chinook salmon	None (until status is determined)	0	0
Coyote Valley Fish Facility			
Steelhead	Isolated harvest	200,000 yearling	480

[1]As defined in NOAA Fisheries' current template for Hatchery and Genetic Management Plan (HGMP), available at www.nwr.noaa.gov, an *isolated harvest program* is "a project in which artificially propagated fish produced primarily for harvest are not intended to spawn in the wild or be genetically integrated with a specific natural population." An *integrated recovery program* is "an artificial propagation project primarily designed to aid in the recovery, conservation or reintroduction of particular natural population(s), and fish produced are intended to spawn in the wild or be genetically integrated with a targeted natural population(s), sometimes referred to as 'supplementation.'" It is assumed that an *integrated* program is more desirable than an *isolated* program as a means of minimizing potential genetic effects; however, the risk cannot be evaluated until current evaluations of genetics and stock origin are completed. Original mitigation and enhancement goals took into account harvest activities on all species; however, harvest is currently permissible only for hatchery steelhead. A continued harvest is assumed as a long-term goal for the steelhead program based on apparent stability of the hatchery stock. A recovery goal is assumed for the coho salmon program, which has already begun implementation of a restoration program to avoid the risk of extinction.

[2]Broodstock spawning-number goals reflect the estimated minimum number necessary to achieve juvenile release goals, or the minimum necessary to maintain genetic integrity, whichever is greater. The steelhead broodstock numbers incorporate the current spawning protocol of using 2.5 males for every 1 female.

4.6.3 Steelhead Isolated Harvest Program

The current uncertainty regarding genetic divergence that may have occurred between the natural and hatchery steelhead stocks within the Russian River basin provides justification for an "isolated" program.

The proposed isolated harvest program for steelhead would continue the objectives of the existing steelhead mitigation program. The program would collect returning hatchery-reared steelhead and use them as broodstock to produce fingerling. The fingerling would be subsequently released as smolts directly in Dry Creek, or transported to CVFF for acclimation and volitional release in the upper Russian River basin. The objectives of the isolated harvest mitigation program are to: 1) compensate for the loss of steelhead production behind Warm Springs Dam and Coyote Valley Dam; 2) provide a fishery for hatchery-reared steelhead in the Russian River basin; and 3) minimize ecological interactions with the wild Russian River steelhead population by purposefully striving to isolate the spatial and temporal overlap of habitat utilization by the wild and hatchery-reared components.

The time-frame necessary to measure and evaluate the objectives is estimated to be a minimum of three generations, so that a statistically significant number of samples can be obtained for analysis. For the isolated harvest alternative, this time-frame is estimated to be 15 years, assuming 5 years to be the average length of a steelhead generation.

4.6.3.1 Broodstock Selection and Mating

The isolated harvest program would derive all broodstock from the supply of adult steelhead returning to the hatchery. Broodstock for the DCFH program are collected from fish returning to the DCFH ladder and trap, while those for the CVFF program are collected from fish returning to the CVFF ladder and trap. All wild adult steelhead returning to DCFH are relocated to tributary streams of Dry Creek, and all wild adult steelhead returning to CVFF are relocated to the west branch of the Russian River above Mumford Dam or on the East Fork near Forsythe Creek. In a change to past protocols, all surplus hatchery adult steelhead returning to the fish facilities would not be returned to the watershed, but would be destroyed to minimize potential interactions with naturally-spawning fish. Table 4-10 summarizes the proposed annual broodstock spawning numbers for steelhead.

Table 4-10 Proposed Annual Broodstock Minimum Spawning Numbers for Steelhead

	DCFH	CVFF
Females	180	120
Males (including jacks)	450 (incl. 3 jacks)	300 (incl. 2 jacks)

4.6.3.2 Rearing and Release

Proposed rearing operations for the steelhead program would continue the methods currently practiced, as described in Section 3.8. The proposed annual fish-release levels for steelhead are summarized in Table 4-11. All steelhead would be released as smolts and there would be no releases of fry, fingerling, or surplus fish.

Table 4-11 Proposed Annual Steelhead Release Levels by Lifestage and Location

Lifestage	Maximum Number	Size (fish per pound)	Release Date	Release Location
Eyed Eggs	0	NA	NA	NA
Unfed Fry	0	NA	NA	NA
Fry	0	NA	NA	NA
Fingerling	0	NA	NA	NA
Yearling – DCFH	300,000	4	Jan - Apr	Dry Creek (Yoakim Bridge)
Yearling – CVFF	200,000	5	Jan - Apr	East Fork Russian River (CVFF)

Yearling smolt steelhead from DCFH would be released in Dry Creek, 3 miles downstream from the hatchery at Yoakim Bridge. Yearlings from CVFF would be released at the discharge point of the CVFF facility. DCFH releases would be forced, while CVFF releases would be volitional during a 1-month acclimation period, and then forced at the end of the period. Because fish released from the DCFH are spawned, incubated, and reared in the water in which they are released, they would be acclimated for their entire juvenile lifestage. Fish released at CVFF would be transported to the facility from DCFH approximately 30 days before their release. The proposed release sizes for DCFH and CVFF steelhead are a larger size than their naturally-spawned counterparts at the same age.

4.6.3.3 Harvest Management

Current fishing regulations allow the take of hatchery-reared steelhead. (All steelhead released from DCFH and CVFF are marked with clipped adipose fins.) Harvest of naturally-spawned steelhead is prohibited. There are no current estimates of harvest levels of steelhead within the Russian River, but there is indication that funding soon may be available for a project to estimate harvest levels (Royce Gunter, CDFG, pers. comm. January 8, 2002). It is assumed that the existing steelhead harvest practices would be continued under the proposed project, unless the results of monitoring indicate that harvest practices are negatively affecting the naturally-spawned population level.

4.6.3.4 Monitoring and Evaluation

Monitoring and evaluation of critical areas will be conducted to ensure that the steelhead isolated harvest program is operating in a successful manner. Criteria indicating a successful isolated harvest program include:

1. The numbers of adult hatchery-reared steelhead returning to the Russian River basin (including those harvested by recreational fishers) meet or exceed the minimum broodstock spawning numbers plus any established harvest goals.

2. Population assessments indicate a stable or increasing trend in the number of adult steelhead returning to spawn in the Russian River, with measured adult-to-adult replacement greater than or equal to one. This population assessment includes adults of both the hatchery-reared and naturally-spawned components.

3. Population assessments conducted in release streams indicate no change or an increase in abundance of the wild population.

4. Genetic assessments of both the wild and hatchery-reared components conducted over time show no loss or an increase of genetic variation in either component; divergence of the two components are acceptable, depending on the desired level of stock isolation.

Greater detail regarding the biological basis for these criteria can be found in the BRA document (FishPro and ENTRIX, Inc. 2002). Performance indicators, as well as plans proposed for monitoring and evaluation of those indicators, are presented in the draft DCFH steelhead HGMP (FishPro and ENTRIX, Inc. 2003).

4.6.4 Coho Salmon Integrated Recovery Program

The proposed captive broodstock program for coho salmon would have similar objectives to the existing CDFG pilot captive broodstock program. The program would continue to collect naturally-produced juvenile coho salmon, rear the fish to maturity, and use them as broodstock to produce fingerlings. The fingerlings would be released into appropriate streams in the Russian River basin. The objectives of the captive broodstock program are to: 1) prevent extirpation of Russian River coho salmon; 2) preserve genetic, ecological, and behavioral attributes of Russian River coho salmon while minimizing potential effects to other stocks and species; and 3) build a naturally-sustaining coho salmon population. The program serves a secondary purpose of research, providing information on the effective use of artificial propagation to address other goals. Any changes to the existing pilot captive broodstock program will require analysis and approval via amendments to the existing Section 10 permit for the program.

The time-frame necessary to measure and evaluate the objectives is estimated to be a minimum of five salmon generations, so that a statistically significant number of samples can be obtained for analysis. For the captive broodstock program, an additional 4 years of start-up time is necessary to allow for broodstock growth to sexual maturity following the initial capture of adults.

4.6.4.1 Broodstock Selection and Mating

The proposed program calls for the collection of 300 to 600 juvenile coho salmon annually for potential use as broodstock, followed by rearing in captivity until the fish reach maturity. Electrofishing for juvenile coho salmon from selected streams will be conducted between March and November. Procedures for electrofishing will be employed as specified in Permit 1067 (NMFS 2001a). Broodstock would be collected from a random selection of juvenile coho salmon encountered during each electrofishing capture event. To preserve the naturally-reproducing component of the stock, no more than 50 percent of the juvenile fish encountered will be collected.

Determination of the specific streams to be surveyed each year as potential broodstock sources will be developed in consultation with NOAA Fisheries and the Technical Oversight Committee (TOC) as long as it is active. The preferred source for broodstock is within the Russian River basin. Streams identified as possible sources include Green Valley, Purrington, Freezeout, Willow, Ward, Sheephouse, and Felta creeks. If insufficient numbers are obtained after initial collection efforts, additional collection may be conducted if suitable watersheds can be identified. The risks of inbreeding versus outbreeding depression would be carefully weighed before out-of-basin transfer would occur. Collection efforts will be adjusted as genetic information is developed on the relationships between Russian River stocks and populations in other candidate watersheds.

In September 2001, 344 juveniles were collected in the Russian River basin, mostly from Green Valley; 301 of these juveniles were on hand as of July 2003. For the subsequent 2002-year class of captive broodstock, 458 juvenile coho salmon were on hand as of July

2003, collected from Green Valley, Mark West, and Dutch Bill creeks in the Russian River basin. Gender proportions have not yet been determined. Assuming a spawn of 100 females, there will be an egg take of roughly 230,000 for each year class.

The TOC will evaluate the best strategies to increase genetic diversity during the initial captive brood maturation period, and will make a recommendation before the first spawning anticipated in late 2003 or early 2004. State-of-the-art genetic analyses will be conducted for all fish used in the program, and the results of the analyses will be used to dictate the combinations of mature coho salmon to use in the spawning process.

Most coho salmon mature in their third year, but some fish, typically males, will mature a year early. It is possible that some captive brood will mature early, and/or it may be possible to induce precociousness through hormone treatments. The TOC will evaluate the potential benefits of using precocious males to transmit genetic material between year classes, thereby increasing genetic diversity and/or supplementing weak year classes. The TOC will evaluate the feasibility of cryopreservation of milt and the cost of associated equipment and implementation, and provide the findings in the first annual report for the program.

4.6.4.2 Rearing and Release

As of July 2003, the fish on hand for the coho salmon recovery program were introduced into newly constructed facilities at DCFH. The facilities include six intermediate juvenile rearing troughs measuring 16 feet long by 3 feet wide with a 2.5-foot water depth. Also included for the broodstock are six circular tanks, 20 feet in diameter with a 4.5-foot water depth. An additional expansion is planned for 2004 to double the number of troughs and tanks and provide a building enclosure for the area.

Rearing-pond densities for the captive broodstock will be managed so they do not exceed a maximum density of 0.5 pound of fish per cubic foot of space (lb/ft^3). Rearing-pond densities for fish to be released will be held at low densities so they do not exceed 1.5 lb/ft^3. Lower densities will be maintained whenever possible. Fish will be reared to a target-release size that mimics the size of natural fish of the same age, to minimize the risk of predation and competition with natural fish upon release. Table 4-12 summarizes the annual fish-release levels and locations for coho salmon currently proposed by the TOC.

Table 4-12 Proposed Annual Coho Release Levels by Lifestage and Location

Lifestage	Maximum Number	Size (fish per pound)	Release Date	Release Location
Eyed Eggs	0	NA	NA	NA
Unfed Fry	0	NA	NA	NA
Fry	0	NA	NA	NA
Fingerling (advanced size)	100,000 (20,000 each stream)	60	Oct-Nov	5 streams: Willow, Sheephouse, Freezeout, Mill, Ward
Yearling	0	NA	NA	NA

These release levels and locations are being discussed and may evolve further. Additionally, the TOC will make recommendations to NOAA Fisheries regarding disposition of any excess eggs, fry, fingerlings, or smolts beyond the current goal of releasing 100,000 advanced fingerling.

All coho salmon released as part of the coho salmon recovery program will be tagged. Tagging options are currently being discussed by the TOC, including coded wire tags, adipose fin clips, visible implant elastomer markers, and passive integrated transponder tags. Decision-making factors include cost and funding; size at release; and desired level of information regarding parent lineage, stocking stream groups, and year class.

All juvenile fish collected as part of future broodstock collection efforts will be assayed with scanning equipment as relevant for the types of tags used on released fish. Any tagged coho salmon that are captured will be released back to their capture location.

4.6.4.3 Monitoring and Evaluation

Monitoring and evaluation of critical areas will be conducted to ensure that the coho salmon integrated recovery program is operating in a successful manner. Criteria indicating a successful integrated recovery program include:

1. Population assessments indicating an increasing trend in the number of adult coho salmon returning to the Russian River, with measured adult-to-adult replacement greater than or equal to one.

2. Population assessments conducted in release streams indicating no change or an increase in abundance of the naturally-spawning component.

3. Genetic assessments of both the naturally-spawning and hatchery-reared components conducted over time, showing no loss or an increase of genetic variation in each component.

Performance indicators, as well as plans proposed for monitoring and evaluation of those performance indicators, are presented in the DCFH coho salmon HGMP (FishPro and ENTRIX, Inc. 2003).

A long-term comprehensive monitoring program for stream condition and adult and juvenile abundance is being developed by the capture, release, and monitoring subcommittee of the Russian River Coho Salmon Recovery Workgroup.

4.6.5 Facility Changes

Existing hatchery facilities and proposed modifications to DCFH are described in detail in the draft HGMPs for steelhead and coho salmon. This section summarizes proposed water supply modifications that will enhance both the steelhead and coho salmon programs conducted at DCFH.

4.6.5.1 Water Supply Modification

The total DCFH water demand for the fish production aspects of the baseline mitigation program is 25 cfs. When broodstock collection and holding operations are also occurring, the demand increases to approximately 35 cfs to operate the fish ladder and maintain the captured fish in the holding ponds. Currently, water for the hatchery is taken from the outlet works of the stilling basin of Warm Springs Dam. An emergency water supply is used to supply a sufficient quantity of water to the hatchery when the outlet works and power plant are not operating.

A new water supply would be constructed for the DCFH that would tap into the existing wet well and provide a single pipeline capable of delivering 50 cfs of gravity-flow reservoir water to the DCFH facilities. The new water supply will eliminate the need for the emergency water supply system, and the existing emergency supply pipeline would be removed. A feasibility study to determine the best design option is planned for 2004, with possible construction occurring in 2007 or later.

4.6.6 Future Supplementation Programs

As part of the regulatory framework provided by ESA, NOAA Fisheries has established nine domains spanning the geographic range of listed West Coast salmon and steelhead, with the intent of developing comprehensive recovery plans for all listed ESUs within each domain. The Russian River is located within the North-Central California Coast domain. Some of the initial efforts that will be completed through the recovery planning process are: 1) an evaluation of the current status of the listed population or species; 2) an assessment of the factors affecting the species; and 3) an identification of recovery (delisting) goals. As new information on the status of Russian River populations becomes available from the recovery planning, it may become appropriate to use the DCFH and CVFF to support recovery efforts differently than the programs proposed in the previous section.

As previously described, the recommended hatchery programs under the proposed project include: 1) an isolated harvest program for steelhead; 2) a supplementation program for coho salmon; and 3) "no production" for Chinook salmon. If new information indicates it is warranted, alternative hatchery production programs for each of the three listed species may be implemented. The programs would be formulated to have the least possible effect on the wild populations for each of the three listed species, given the current understanding of each species' population and genetic characteristics.

The use of hatcheries to supplement wild stocks is a controversial topic, in part due to confusion over the definition of the term. NOAA Fisheries (Flagg et al. 2000) suggests the most practical definition may be:

> *Supplementation is the stocking of fish into natural habitat to increase abundance of naturally reproducing fish populations.*

NOAA Fisheries has recommended that supplementation of a population may be appropriate if (Flagg et al. 2000):

- The wild population is declining.
- Sufficient spawning habitat is available and underused.
- Other actions that could address the cause(s) of population declines cannot be implemented in a timely manner.
- Hatchery technology and facilities are available to increase stock productivity above replacement.

The DCFH and CVFF provide a rare opportunity for rapid implementation of a supplementation program, should the conditions described above be found to exist for steelhead or Chinook salmon in the Russian River. A proposed program for steelhead production, referred to as an integrated harvest, is presented below. This program for steelhead differs from the isolated harvest program described above, primarily in the use of wild steelhead broodstock rather than returning hatchery-reared fish, thus reducing the risk of genetic effects to the wild population. The implementation of this program assumes that the wild steelhead population is stable or increasing, which again is dependent on the results of population studies likely to be completed through recovery planning efforts. In addition, a Chinook salmon supplementation program is described and analyzed, in case future data show the Russian River Chinook salmon population to be below the viable population threshold. (Coho salmon are not considered in this analysis because the proposed coho salmon program presented in the BA consists of supplementation.)

4.6.6.1 Steelhead Integrated Harvest Program

Program Objectives

The proposed future integrated harvest program for steelhead would meet the objectives of the existing steelhead enhancement program, except that wild steelhead trout would be used as broodstock to eliminate genetic differences between the hatchery-reared and naturally-spawning components. Additionally, the integrated harvest program would include a supplementation component to compensate for the numbers of broodstock collected from the wild, as well as to increase the population of naturally-spawning steelhead. The objectives of the integrated harvest enhancement program are to:
1) provide a fishery for hatchery-reared steelhead in the Russian River basin;
2) contribute to the naturally-spawning steelhead population at a level greater than the level of broodstock collection from the wild; and 3) preserve genetic, ecological, and behavioral attributes of wild Russian River steelhead while minimizing potential effects to other stocks and species.

Criteria for evaluating success of the integrated harvest program involve measurement of the following critical areas:

- The numbers of adult hatchery-reared steelhead returning to the Russian River basin (including those harvested by recreational fishers) meet or exceed the escapement goals.

- Population assessments indicate an increasing trend in the number of adult steelhead returning to the Russian River, with measured adult-to-adult replacement greater than or equal to one. This population assessment would include adults of both the hatchery-reared and naturally-spawned components, because presumably there would be no genetic difference between the two components.

- Population assessments conducted in release streams indicate no change or an increase in abundance of the naturally-spawning component.

- Genetic assessments of both the naturally-spawning and hatchery-reared components conducted over time show no loss or an increase of genetic variation in each component.

Estimated Time-Frame to Achieve Objectives

The time-frame necessary to measure and evaluate the objectives of a steelhead integrated harvest program is estimated to be 17 years. This includes a period of three generations, so that a statistically significant number of samples could be obtained for analysis. Assuming 5 years to be the average length of a steelhead generation, the period of three generations is 15 years. An additional 2 years of start-up time is necessary to allow for the first cycle of adult collection and fingerling production.

Program Description

The steelhead supplementation program recommended for the Russian River basin would consist of the following components:

- Wild adult steelhead would be collected at a location downstream of the supplementation stream-release location. A broodstock collection goal of 269 wild adult steelhead has been established based on consideration of several factors including minimum effective population size, estimated productivity of the wild population, and estimated smolt-to-adult return rate for the hatchery population (Table 4-13). It is assumed that an adult trapping, sorting, and collection facility would be developed at a suitable location before implementation of the supplementation program. (Wild broodstock collection at the existing DCFH and CVFF traps is not feasible because there is no spawning habitat upstream of the traps, and thus no measures for attracting wild fish into the traps.)

- The wild steelhead broodstock would be transported to existing holding facilities at DCFH and would be spawned there when ripe. The same site would be used to provide incubation of 638,500 eggs and rearing facilities for 500,000 pre-smolt fingerling. Though these fish are the progeny of wild broodstock, all fish will be marked with a coded wire tag or similar unique marker to identify them as hatchery-reared fish.

Table 4-13 Steelhead Integrated Harvest Program: Assumed Conditions and Facility Production Guidelines

	DCFH	CVFF	Supplementation Streams
Minimum number broodstock collected	161	108	NA
Spawning male:female ratio	1:1	1:1	NA
Pre-spawning survival	95%	95%	NA
Females spawned	77	51	NA
Fecundity	5,000	5,000	NA
Total egg take	383,100	255,400	NA
Survival – egg take to fry ponding	87%	87%	NA
Total fry ponded	333,300	222,200	NA
Survival – ponding to smolt release	90%	90%	NA
Total F_1 smolt released or transferred	300,000	200,000	NA
On-site releases	230,000	200,000	70,000
Supplementation stream transfers	70,000	0	0
Size at smolt release	6.8 inches	6.8 inches	6.8 inches
Period of smolt release	Jan-Apr	Jan-Apr	Jan-Apr
Survival – smolt release to adult return	1.0%	1.0%	1.0%
F_1 adults returning (before harvest)	2,300	2,000	700
Estimated harvest (15%)	345	300	105
Broodstock reserve (use F_2 if available)	161	108	0
Fish passed for natural spawning	0	0	595
Est. productivity of naturally-spawned pop.	NA	NA	0.5
Estimated wild (F_2) adult return	NA	NA	298
Target F_2 broodstock collection	NA	NA	269

- Smolts would be released from at least three locations. A total of 200,000 smolts would be released into the East Fork Russian River through volitional release from CVFF following a 1-month acclimation period (as with the existing isolated harvest program). Another 230,000 smolts would be released directly into Dry Creek from DCFH. The final 70,000 smolts would be used to supplement the naturally-spawning population by releasing the fish into one or more selected streams having total available spawning capacity for approximately 700 steelhead adults. As hatchery-reared fish, all adults returning from these smolt releases will be subject to harvest. However, assuming a harvest rate of 15 percent, approximately 595 fish would return to the supplementation streams, thereby providing sufficient numbers of naturally-spawning broodstock to produce wild steelhead progeny (i.e., the F_2 generation) that can, in turn, serve as wild broodstock for the integrated harvest program without concern for genetic effects. (F_x refers to generations removed from the parental generation. F_1 refers to the progeny of a given parental cross, F_2 refers to the offspring of those progeny. For example, F_1 refers to children and F_2 refers to grandchildren.)

- An annual monitoring and evaluation plan will be implemented to evaluate, at a minimum: 1) the population abundance of both hatchery-reared and naturally-spawned adults returning to the Russian River, as measured at the adult collection facility; 2) the population abundance of the specific release streams; and 3) a genetic assessment of both the naturally-spawning and hatchery-reared components conducted over time to assure no loss of genetic variation in each component. Additional monitoring parameters are recommended in the HGMP.

4.6.6.2 Chinook Salmon Supplementation Program

Program Objectives

The Chinook salmon supplementation program would collect wild returning adult Chinook salmon and use them as broodstock to produce fingerlings in the hatchery. The fingerlings would be subsequently seeded into appropriate streams in the Russian River basin. The objectives of the supplementation program are to: 1) prevent extirpation of Russian River Chinook salmon; 2) preserve genetic, ecological, and behavioral attributes of Russian River Chinook salmon while minimizing potential effects to other stocks and species; and 3) build a naturally-sustaining Chinook salmon population.

Criteria for evaluating success of the supplementation program are:

- Population assessments indicate an increasing trend in the number of adult Chinook salmon returning to the Russian River, with measured adult-to-adult replacement greater than or equal to one. This population assessment would include adults of both the hatchery-reared and naturally-spawned components, because presumably there would be no genetic difference between the two components.

- Population assessments conducted in release streams indicate no change or an increase in abundance of the naturally-spawning component.

- Genetic assessments of both the naturally-spawning and hatchery-reared components conducted over time show no loss or an increase of genetic variation in each component.

Estimated Time-Frame to Achieve Objectives

The time-frame necessary to measure and evaluate the objectives of a Chinook salmon supplementation program is estimated to be 17 years. This includes a period of five generations, so that a statistically significant number of samples could be obtained for analysis. Assuming 3 years to be the average length of a Chinook salmon generation, the period of five generations is 15 years. An additional 2 years of start-up time is necessary to allow for the first cycle of adult collection and fingerling production. A secondary factor in selecting program duration is an assumption that habitat restoration efforts within the Russian River may require 10 to 20 years.

Program Description

The Chinook salmon supplementation program recommended for the Russian River basin consists of the following components:

- Wild adult Chinook salmon will be collected at a location downstream of the supplementation stream release location. A broodstock collection goal of 242 wild adult Chinook salmon has been established, based on consideration of several factors including minimum effective population size, estimated productivity of the wild population, and estimated smolt-to-adult return rate for the hatchery population (Table 4-14). It is assumed that an adult trapping, sorting, and collection facility would be developed at a suitable location before implementation of the supplementation program; conceivably, this collection facility could be developed at Mirabel dam. (Wild broodstock collection at the existing DCFH and CVFF traps is not feasible because there is no spawning habitat upstream of the traps, and thus no measures for attracting wild fish into the traps.)

- The wild Chinook salmon broodstock will be transported to existing holding facilities at DCFH and will be spawned there when ripe. The same site will be used to provide incubation of 460,000 eggs and rearing facilities for 360,000 fingerling smolts. All fish will be marked with a coded wire tag or similar unique identifier prior to release.

- The 360,000 fingerling smolts will be released into one or more selected streams having total available spawning capacity for at least 478 Chinook salmon adults.

Table 4-14 Chinook Salmon Supplementation Program: Assumed Conditions and Facility Production Guidelines

Target number wild broodstock	242
Spawning male:female ratio	1:1
Pre-spawning survival	95%
Females spawned	115
Fecundity	4,000
Total egg take	459,800
Survival – egg take to fry ponding	87%
Total fry ponded	400,000
Survival – ponding to smolt release	90%
Total F_1 smolt released	360,000
Size at smolt release	3.6 inches
Period of smolt release	Mar-May
Survival – smolt release to adult return	0.20%
F_1 adults returning	720
Broodstock reserve (prefer F_2)	242
Fish passed for natural spawning	478
Est. productivity of naturally-spawned pop.	0.5
Estimated wild (F_2) adult return	239
Target F_2 broodstock collection	242

- An annual monitoring and evaluation plan will be implemented to evaluate, at a minimum: 1) the population abundance of both hatchery-reared and naturally-spawned adults returning to the Russian River, as measured at the adult collection facility; 2) the population abundance of the specific release streams; and 3) a genetic assessment of both the naturally-spawning and hatchery-reared components conducted over time to assure no loss of genetic variation in each component.

4.7 Required Changes to Institutional Agreements and Constraints

To implement the proposed changes and modifications to the facilities and operations described in the preceding sections, several of the existing Institutional Agreements and Constraints described in Section 1.4 will require revision. This section identifies and briefly describes the required changes.

4.7.1 SWRCB Decision 1610

D1610 and SCWA's water-rights permits specify the existing minimum flow requirements for Dry Creek and the Russian River (Section 1.4.3). SCWA's permits will need to be amended so that the Flow Proposal and Estuary management protocols as described in Section 4.3 may be implemented.

4.7.2 WARM SPRINGS DAM HYDROELECTRIC FACILITY

The FERC license granted to SCWA for the Warm Springs Dam hydroelectric facility that incorporated the D1610 minimum flow requirements (Section 1.4.2.2). Because proposed Dry Creek flows will be less that the D1610 minimums that were incorporated into the FERC license, amendment of the FERC license will be required.

Under SCWA's power sale contract with PG&E, SCWA receives "capacity" payments from PG&E in addition to payments for power actually delivered. The capacity payments are based upon a "firm capacity" of 1.246 megawatts during the summer months. Because the hydroelectric turbines at Warm Springs Dam cannot be operated at flows less that 70 cfs, SCWA would be not be able to provide the "firm capacity" contemplated by the power sale agreement with PG&E. This will result in reduced revenue to SCWA and the possible de-rating of the capacity of the Warm Springs Dam hydroelectric facility. The contract expires in 2006.

4.7.3 FLOW BYPASS FOR COYOTE VALLEY DAM

In order to provide bypass flows during dam inspections, the USACE will need to install pumps and a pipeline to deliver the water from Lake Mendocino to East Fork Russian River (described in Section 4.1). Installation of the bypass system at Coyote Valley Dam would require congressional approval and funding.

4.7.4 USACE CHANNEL MAINTENANCE REQUIREMENTS

The channel maintenance requirements of the USACE are inconsistent with the channel maintenance procedures proposed in Section 4.4. The USACE would need to revise their channel maintenance requirements to reflect the implementation of focused channel maintenance and vegetation clearing activities that provide greater protection for listed fish species. The existing O&M manuals for the CVDP and WSDP were authorized by Congress.

4.7.5 FISH PRODUCTION FACILITIES

The current mitigation goals established for the fish production facilities for coho and Chinook salmon are inconsistent with the proposed operations of the fish facilities in Section 4.6. Steelhead production will maintain existing mitigation goals. The existing mitigation and enhancement goals for coho will be put on hold for the duration of the coho salmon recovery program, which is currently scheduled to expire in 2007. The existing mitigation and enhancement goals for Chinook salmon will be put on hold and there will be no Chinook salmon production, unless directed otherwise by NOAA Fisheries and CDFG. A formal revision of the mitigation and enhancement obligations for USACE for coho salmon, steelhead, and Chinook salmon will be completed when the USACE, NOAA Fisheries, and CDFG determine new goals that would be consistent with recovery plans and make the best use of fish production facilities and operations.

This section evaluates the effects and benefits of the proposed project on coho salmon, steelhead, and Chinook salmon within the action area in the Russian River watershed. Evaluation criteria outlined in Appendix C are applied to evaluate components of the proposed project described in Section 4.

Section 5.1 assesses the effects of flood control and hydroelectric facility operations. Operation and maintenance activities at Coyote Valley Dam and Warm Springs Dam are evaluated.

Section 5.2 evaluates the effects of operation and maintenance activities related to the diversion facilities and the water supply and transmission system.

Section 5.3 evaluates the effects of the proposed water management. Effects of the Flow Proposal on flow, water temperature, and DO are evaluated. Effects of additional measures proposed as part of water management are also evaluated. Section 5.3 also assesses the effects of proposed water management on the Estuary. The effects of the proposed Estuary management, including a change in the artificial breaching program, are evaluated.

Section 5.4 evaluates the effects of the proposed channel maintenance activities. Section 5.5 evaluates the effects of restoration and conservation actions.

Section 5.6 evaluates the effects of the proposed fish production facilities. Programs proposed for steelhead and coho salmon, as well as future programs for steelhead and Chinook salmon, are assessed.

Section 5.7 provides a summary of effects.

5.1 FLOOD CONTROL OPERATIONS AND HYDROELECTRIC OPERATIONS

This section examines the effects of Warm Springs and Coyote Valley dams' flood control operations on coho salmon, steelhead, and Chinook salmon in order to characterize their influences on salmonid populations and habitats. The effects of hydroelectric operations at Warm Springs Dam are also discussed in Section 5.1.4.

Flood control operations at Warm Springs and Coyote Valley dams affect water quality, flow regimes, and channel geomorphology in the Russian River and Dry Creek. During flood control operations and dam maintenance activities, flow release rates are adjusted at the dams. The flow-rate adjustments may either decrease or increase flow rates. The rate of change is attenuated in a downstream direction in both Dry Creek and the mainstem Russian River.

Flood control operations at Coyote Valley and Warm Springs dams may affect salmonids in various ways. Potential issues of concern include:

- Changes in turbidity
- Effects on channel geomorphology
  - Scour of spawning gravels
  - Streambank erosion
  - Channel maintenance/geomorphology
- Ramping rates and flow recessions

5.1.1 FLOOD CONTROL AND WATER QUALITY

Flood control operations during the winter runoff period do not have a strong influence on temperature or DO conditions, but do have the potential to effect the amount of turbidity in the Russian River and Dry Creek.

Ritter and Brown (1971) conducted the only known turbidity study in the Russian River associated with the operational effects of Coyote Valley Dam. Land-use changes and development in the Russian River watershed may have altered the sources and amount of turbidity in the Russian River since the Ritter and Brown study was conducted. However, this BA addresses only turbidity associated with operation of Coyote Valley and Warm Springs dams, and does not address other sources of turbidity that may occur in the watershed.

During storm runoff events, sediment naturally enters Lake Mendocino and Lake Sonoma, and finer sediment particles often remain suspended in the water column. During and after storm events, turbid water may be released from Coyote Valley Dam for several days until high flows begin to recede from the flood peak in the downstream channel (Ritter and Brown 1971).

Inflow to Lake Mendocino contains a much higher level of turbidity than inflow to Lake Sonoma (USACE 1986a). Because Lake Mendocino inflow has a relatively short residence time compared with Lake Sonoma, much of the suspended sediment does not settle out. Therefore, flow releases from Coyote Valley Dam are more likely to influence downstream water quality. Historically, Dry Creek has had the least persistently turbid water compared with the Russian River (Ritter and Brown 1971). As tributaries downstream of the dams contribute suspended sediment and streamflow to the mainstem Russian River and Dry Creek, the relative proportion of turbidity originating from flood control activities diminishes farther downstream.

Turbidity associated with high-flow releases is due to fine sediment particles (silts and clays) held in suspension. It is unlikely that much of this fine sediment will settle out in the bed of downstream channels. Silt and clays are readily transported in suspension as wash-load (Reid et al. 1997), and much of this material is either deposited in long-term sediment storage features such as terraces, floodplains, natural river levees, and bars, or is completely transported through the river channel. Thus, turbidity associated with flood control releases is not expected to have a great influence on physical habitat conditions such as spawning gravels, riffles, or pools. Persistent turbidity, however, could affect behavioral activities such as abandonment of cover or short-term reduction in feeding rates. For example, Berg and Northcote (1985) found that feeding and territorial behavior of juvenile coho salmon are disrupted by short-term exposures (2.5 to 4.5 days) to turbid water (up to 60 NTU).

The Water Quality Control Plan for the North Coast Region sets a standard for turbidity as:

> *Turbidity shall not be increased more than 20 percent above naturally occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof.*

The turbidity of water releases from Coyote Valley and Warm Springs dams depends on the duration and intensity of flows into the flood control reservoirs. Ritter and Brown (1971) measured turbidity levels at locations above and below Lake Mendocino in the Russian River and found that periods of persistent water turbidity (greater than 20 mg/l) appear to be generally the same above and below Coyote Valley Dam (Table 5-1). They concluded that water in Lake Mendocino remains turbid about as long as water entering the reservoir remains turbid, and that water releases at Coyote Valley Dam will remain turbid until the water flowing into the lake becomes clear. Based on the Ritter and Brown (1971) study, it appears that discharges from Coyote Valley Dam are within the 20 percent turbidity criteria for the North Coast Region.

Table 5-1 Periods of Persistent Turbidity (> 20 mg/l), East Fork Russian River, 1965 to 1968

	1965	1966	1967	1968
East Fork Russian River near Calpella	Dec. 20-July 16	Nov. 15-May 20	Nov. 15-May 19	Nov. 30-Apr. 15
East Fork Russian River near Ukiah	Dec. 21-May 19	Nov. 17-July 19	Nov. 18-June 7	Dec. 2-Apr. 19

Source: Ritter and Brown (1971)

The Russian River is naturally turbid during the winter and spring runoff. If Lake Mendocino did not exist, the turbid water that enters the lake would have flowed down the East Fork unobstructed and the turbidity of Russian River water would have increased between storm events. Instead, Lake Mendocino interrupts the turbid flows on the East Fork. Thus, when releases from the lake are low for several days following flood flow releases, the water on the Russian River becomes clear (Ritter and Brown 1971). This condition probably would not have occurred if Coyote Valley Dam did not exist, indicating that flood control operations are unlikely to increase turbidity in the mainstem or to affect listed salmonids.

5.1.2 EFFECTS OF FLOOD CONTROL OPERATIONS ON CHANNEL GEOMORPHOLOGY

Flood control operations attenuate floods by storing stormwater discharge in reservoirs. By releasing the stored water more slowly into the Russian River, flood operations damp-out peak flows and increase the duration of moderate flows in mainstem channels.

Flood control activities result in a change in the natural hydrograph, which may alter the geomorphic function of the system. *Interim Report 1* (ENTRIX, Inc. 2000a) examined flood control activities in the Russian River and identified three potential effects of flood control operations on channel geomorphology: the scour of salmonid redds, increased streambank erosion, and the reduction of channel maintenance flows. Appendix C provides evaluation criteria and analysis methodology for these studies.

5.1.2.1 Scour of Spawning Gravels

While flood control activities at Warm Springs and Coyote Valley dams reduce the magnitude of flood peaks in the Russian River, the magnitude and duration of flood releases may still be sufficient to mobilize the streambed, resulting in the loss of incubating embryos. The potential for redd scour was evaluated in three reaches, between Cloverdale and Ukiah (Upper Russian River), in the Alexander Valley (Middle Russian River), and in Dry Creek. Chinook salmon and steelhead typically spawn in the Upper Russian River, while all three species may spawn in Dry Creek. Chinook salmon spawning was documented in Dry Creek in 2003 (A. Harris, SCWA, pers. comm. 2003). The analysis showed that on the mainstem Russian River, redd scour can occur during high winter flows in the absence of flood control releases and that the frequency of redd scour increases with distance downstream from the dam.

The potential for redd scour was estimated by determining the percent of flows in each reach, over a 36-year period (1960 to 1995), that resulted in the mobilization of spawning gravels sufficient to expose the egg pocket of the redd. It is expected that the flood flow regime developed from this 36-year period of record would be similar to the flood flow regime in the future under the proposed project. Each species uses a different size of spawning gravel and each size of spawning gravel responds differently to floods. To characterize gravel, geomorphologists use the median size of gravel, D50, as measured by the diameter of a particle. The D50 means that 50 percent of the population of particle sizes (i.e., spawning gravel bed material) is equal to or finer than the representative particle diameter. Chinook salmon spawn in gravels with a D50 of 36 mm, steelhead spawn in gravels with a D50 of 22 mm, and coho salmon spawn in gravels with a D50 of 16 mm. These D50 are based on a compilation of spawning gravel particle sizes reported from numerous studies on streams throughout the western states (Kondolf and Wolman 1993). From here on, this report uses the terms “Chinook spawning gravels,” “steelhead spawning gravels,” and “coho spawning gravels” to refer to a particle size composition of streambed material with the respective D50 listed above.

Scour events that occur later in the spawning and incubation season are more detrimental than those that occur earlier because they have the greatest potential to scour the most redds and incubating alevins. Late-season high flows that disrupt spawning gravels with incubating eggs will likely have a greater adverse effect on reproductive success for that year's class.

Table 5-2 presents the results of the spawning gravel scour analysis. A score of 1 indicates the highest frequency of scour, and a score of 5 indicates the lowest frequency of scour. Appendix C presents a more detailed explanation of the evaluation criteria and analysis.

Table 5-2 Spawning Gravel Scour Scores (Percent), by Location, for a 36-Year Period (1960 to 1995)

Score*	Ukiah to Alexander Valley (near Cloverdale)		Alexander Valley		Dry Creek		
	Steelhead	Chinook	Steelhead	Chinook	Steelhead	Chinook	Coho
5	2.8	2.8	2.8	11.1	22.2	47.2	13.9
4	55.6	0	5.6	11.1	16.7	11.1	5.6
3	41.7	97.2	33.3	63.9	33.3	27.8	16.7
2	0	0	58.3	13.9	27.8	13.9	22.2
1	0	0	0	0	0	0	41.7

*Score of 5 indicates least scour, 1 indicates most scour.

Upper Reach Russian River

Table 5-2 summarizes the results of the spawning gravel scour evaluation between Ukiah and Cloverdale. The evaluation indicates steelhead gravels were relatively stable. A total of 26 cross-sections were analyzed in this reach for both steelhead and Chinook salmon. Of these 26, 9 cross-sections (35 percent of the total 26) never showed initiation of movement for steelhead gravel sizes. Therefore, the assigned scores were always better than 1 or 2. In one of the 36 years analyzed (e.g., 2.8 percent of the time), steelhead gravels at no more than 10 cross-sections (e.g., 38 percent of the total 26) experienced initiation of motion, thus earning a score of 5. In 55.6 percent of the years analyzed (e.g., 20 years of the 36 evaluated), 65 percent of the cross-sections (e.g., up to 17 cross-sections) experienced scour, earning a score of 4. For 41.7 percent of the 36 years evaluated (e.g., 15 years), up to 17 cross-sections experienced scour during the latter part of the incubation season (May 1–May 30), earning a score of 3. In this case, the lower score of 3 is assigned because the scour occurs during the latter part of the incubation season. This is in contrast to those years when a score of 4 was assigned, even though the same number of cross-sections, 17, experienced scour with a similar frequency over the 36-year-period analyzed.

Chinook salmon spawning gravels (i.e., the median-size gravel used by Chinook salmon) were moved more frequently than steelhead spawning gravel, even though Chinook salmon spawning gravels are larger and less apt to be mobilized. This is because Chinook salmon spawn earlier in the year than steelhead, so that more scouring events take place after Chinook salmon have completed spawning, subjecting eggs to a greater risk of scour. Therefore, the potential for negative effects on incubation are greater.

Of the 26 cross-sections, 16 never showed initiation of movement for the gravel sizes Chinook salmon use. Therefore, the scores earned were always better than 1 or 2. However, in 97.2 percent of the years analyzed (35 out of 36 years), 10 of the 26 cross-sections (38 percent) were scoured during the incubation season (February 1–March 30), earning a score of 3.

In general, Chinook salmon spawn only through January, while their incubation period extends through March. High flows are frequent in February and March where redd loss cannot be replaced by subsequent spawning. Thus, scour of Chinook salmon spawning gravels occurs more frequently than steelhead during their sensitive incubation period, indicating that Chinook salmon redds are more susceptible to scour from high winter flows.

Middle Reach Russian River

Table 5-2 summarizes the data for the Alexander Valley or Middle Reach. A total of 30 cross-sections were analyzed for both Chinook salmon and steelhead. Redd scour was more frequent in the Middle Reach than in the Upper Reach, due to flow accretion from downstream tributaries.

Of the 30 cross-sections, steelhead spawning gravels at only 1 cross-section never experienced scour over the range of flows evaluated in the 36-year period of record. For 58 percent of the years (e.g., 21 years), steelhead spawning gravels were assigned a score of 2. The score of 2 is a result of scour at 29 cross-sections during the December 1–April 30 period, although no scour occurred during the later incubation period (May 1–May 31). For 33 percent of the years analyzed (e.g., 12 years), up to 22 cross-sections out of 30 (75 percent) experienced scour during the earlier spawning season (December 1–April 30), earning a score of 3. There were 2 years (5.6 percent frequency) when scour occurred at less than one-half of the 30 cross-sections, earning a score of 4, and only 1 year (2.8 percent) when less than 25 percent of the cross-sections (up to 7 cross-sections) were scoured, earning a score of 5.

Chinook salmon spawning gravel scores indicate more stable conditions. Of the 30 cross-sections analyzed, spawning gravels at 25 percent (8) never experienced scour, so there were no years that received a score of 1. In 13.9 percent of the years (e.g., 5 years), scour took place at up to 22 cross-sections in the later incubation season (February 1–March 31), earning a score of 2. Scour at up to 22 cross-sections during the earlier spawning season (November 1–January 31) earned a score of 3. A score of 3 was also earned when scour occurred at no more than 15 cross-sections (50 percent) during the later incubation period. In combination, a total of 64 percent of the years analyzed (23 years), resulted in a score of 3. A score of 4 was earned in 11 percent of the years (4 years), indicating scour at up to 15 cross-sections during the earlier spawning season, and a score of 5 was earned in 11 percent of the years, indicating scour at 6 or fewer cross-sections.

While both spawning gravel types scored lower in the Middle Reach mainstem than in the Upper mainstem, Chinook salmon did better in the Alexander Valley than steelhead. This is likely because the smaller steelhead gravels are much less able to withstand scouring under a high-flow regime. Thus, even though steelhead spawn later than Chinook salmon, this advantage is not enough to overcome the scouring effects of the high-velocity flows in the reach. Overall, the larger gravel preferred by Chinook salmon is more resilient to high winter flows in the Middle Russian River mainstem than the smaller steelhead spawning gravel.

Dry Creek

Table 5-2 summarizes the data for Dry Creek. On Dry Creek, flood control operations were evaluated for scour of spawning gravels for all three salmonid species. Significant scour of steelhead and Chinook salmon gravels rarely occurs in Dry Creek. There were 112 cross-sections analyzed on Dry Creek. Steelhead spawning gravels earned a score of 3 or higher in 72 percent of the years, while Chinook spawning gravels received a score of at least 3 or higher in 86 percent of the years.

For steelhead, 27.8 percent of the years analyzed (10 years) received a score of 2, indicating that gravels at up to 108 cross-sections out of 112 (96 percent) experienced scour during the early part of the spawning season. Up to 75 percent of the cross-sections (84 out of 112) experienced scour during the early part of the spawning season (December 1–April 30) in 12 of the years evaluated in the 36-year period of record, earning a score of 3 (33.3 percent). Up to 46 percent of the cross-sections (52 out of 112) scoured in 6 of the years evaluated (16.7 percent), earning a score of 4. Up to 22 percent of the cross-sections (25 out of 112) scoured in 8 of the years evaluated (22.2 percent), earning a score of 5. In almost all years, gravels were never scoured at more than 21 cross-sections during the later incubation period.

For Chinook salmon, 47 percent of the years analyzed (17 years) received a score of 5, indicating that up to 21 cross-sections out of 112 (19 percent) experienced scour. A score of 4 was received in 11 percent of the years (4 years), indicating scour at up to 46 cross-sections (41 percent of the 112 evaluated) during the early part of the spawning season. A score of 2 was earned in 13.9 percent of the years evaluated (5 years), indicating scour at up to 108 cross-sections (96 percent of the 112). None of these scour events occurred during the later incubation season so therefore no years received a score of 1.

Coho spawning gravels faired much more poorly, due to their smaller size and the fact that coho salmon spawn in November through January. Model results indicated that coho redds would have been lost or severely depleted (scores of 1 or 2) in most of the transects in almost 64 percent of the years. The score of 1 indicates that 98 percent of the cross-sections analyzed experienced scour during the later incubation period (February 1–February 28), for 42 percent of the years evaluated. The score of 2 indicates that in 22 percent of the years evaluated, 98 percent of the cross-sections were scoured during the earlier part of the spawning period (December 1–January 31). Coho salmon redds would have faired well (scores of 4 or 5) in almost 20 percent of the years. A score of 5 indicates that up to 25 percent of the cross-sections evaluated experienced scour, and a score of 4 indicates that up to 49 percent of the cross-sections experienced scour during the earlier spawning season. Considering that the streambed should be periodically entrained to flush and transport fine sediments and thereby maintain good-quality spawning gravels, the scores probably indicate a reasonably good balance between streambed mobilization and spawning gravel stability for successful reproduction of Chinook salmon, and an acceptable balance for steelhead. Frequent mobilization of the streambed (by bankfull discharges occurring on average every 1 to 2 years) and by larger floods (exceeding 3- to 5-year annual maximums) are important attributes of adjustable channels that are needed to maintain a balanced sediment budget over the long-term (McBain and Trush 1997). Without a balanced sediment budget, the channel will experience vertical bed instability, either aggradation or degradation.

Coho spawning gravels in Dry Creek are scoured frequently and may result in low incubation success. Given the present geomorphology of Dry Creek, scour of coho spawning gravels would occur in the absence of flood control operations. The narrowing and straightening of the channel from riparian encroachment and channel downcutting may exacerbate scour.

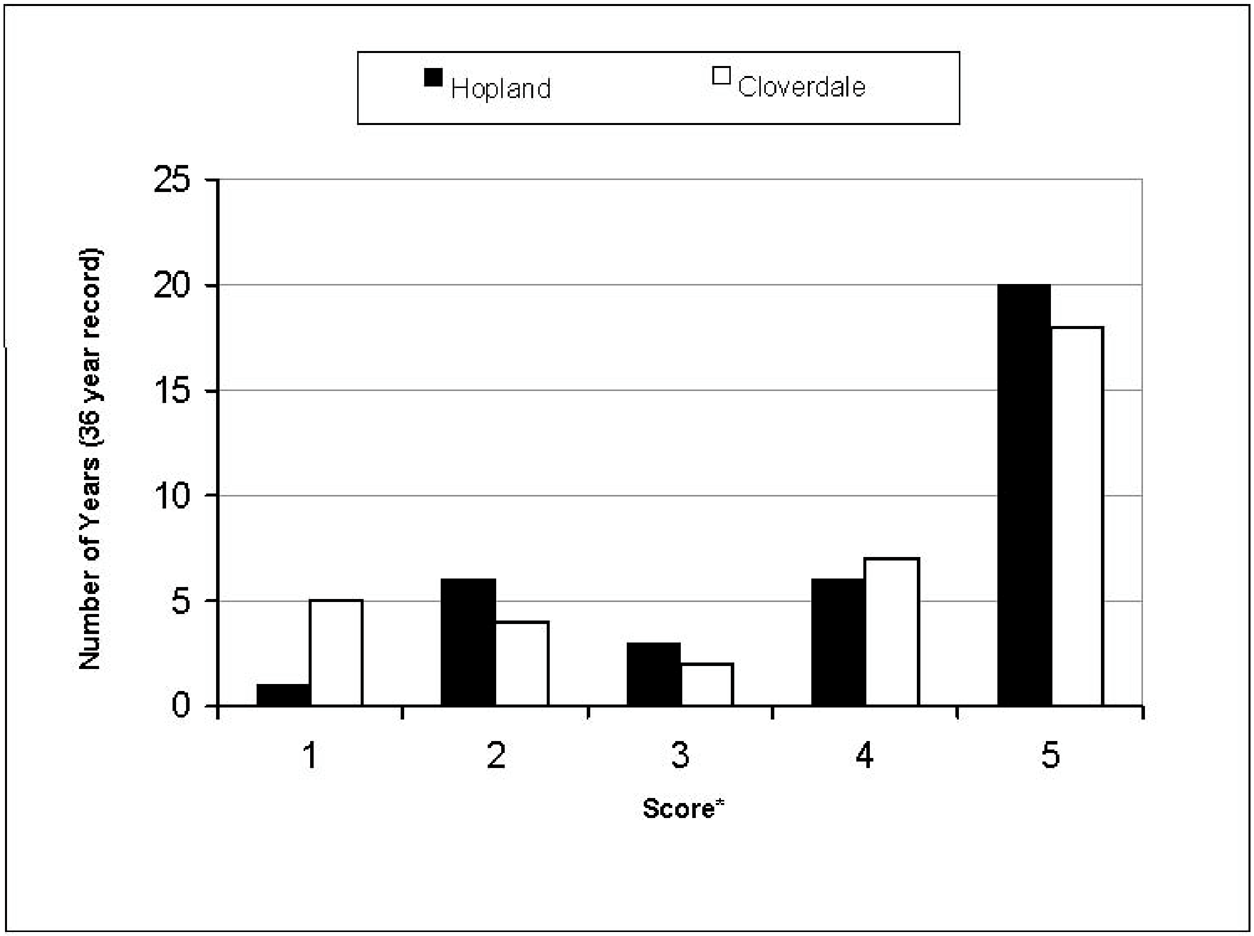
5.1.2.2 Streambank Erosion

Sustained releases of flood flows have been cited as a potential cause of streambank instability on both Dry Creek and the mainstem Russian River. Streambank erosion can temporarily increase sediment loads and reduce habitat complexity. Prolonged discharges in excess of 2,500 cfs are believed to be a cause of accelerated bank erosion on Dry Creek (USACE 1999a). For the mainstem Russian River, there are also no reports that specify which mainstem reaches are subject to erosion, except that “high sustained releases erode the river bank for miles downstream” (USACE 1999a). At flow thresholds of 6,000 cfs at Hopland and 8,000 cfs at Cloverdale, bank erosion is assumed to occur. Appendix C presents the basis for these conclusions.

Mainstem Russian River

Using threshold values of 6,000 cfs at Hopland and 8,000 cfs at Cloverdale, streamflows above these values were tallied on an annual basis for water years 1960 to 1995. The greater the number of days that exceeded these thresholds in a given year, the greater the likelihood of streambank erosion and the lower the score. Figure 5-1 is a frequency histogram showing these scores. Most years receive a score of 5 at both locations evaluated. At Hopland, 80 percent of the 36-year period of record (29 years) received a score of 3 or better. At Cloverdale, 75 percent of the 36-year period of record (27 years) received a score of 3 or better.

It is noteworthy that on many of the days when flows exceeded the erosion threshold, discharge from Coyote Valley Dam was low. For example, in 1995 there were 12 days when flows exceeded the 6,000-cfs erosion threshold, but the release from Coyote Valley Dam never exceeded 600 cfs, and was usually only 35 cfs. At Cloverdale, there were 21 days when flows exceeded the 8,000-cfs erosion threshold. But on only three of those days, releases from Coyote Valley Dam increased the total downstream discharge.



* Number of years receiving calculated score over the period of record analyzed. Lower scores are indicative of years with relatively greater number of bank erosion events; higher scores indicate relatively fewer bank erosion events, for the number of years shown in the graph.

Figure 5-1 Frequency Histogram of Bank Erosion Scores on Mainstem Russian River, 1960 to 1995

To minimize bank erosion, flood control operations are often timed so that reservoir outflows constitute a relatively insignificant portion of the total streamflow at Hopland or Cloverdale. The analyses indicate that flood operations at Coyote Valley Dam do not cause prolonged flows above the threshold at which streambank instability and erosion begin in the Upper and Middle Reaches of the Russian River.

Dry Creek

Streambank erosion on Dry Creek occurs when sustained flows exceed 2,500 cfs (USACE 1999a). To assess the effects of flood control operations on erosion, streamflows above 2,500 cfs were tallied on an annual basis for the water years 1960 to 1995. The greater the number of days that exceed 2,500 cfs in a given year, the greater the likelihood of streambank erosion and the lower the score.

Table 5-3 shows bank erosion scores for two Dry Creek locations (immediately below Warm Springs Dam and near Geyserville) by water year. The Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system. Figure 5-2 is a frequency histogram showing the Dry Creek bank erosion scores.

As shown in Table 5-3, a score of 5 was assigned to about half of the years analyzed (18 of 36 years) near Geyserville, indicating that flows did not exceed 2,500 cfs more than 3 days per year. However, a score of 1 was assigned to 10 of the 36 years in the water record. Thus, in approximately 28 percent of the years, flows exceeded 2,500 cfs for more than 16 days and streamflow conditions were highly conducive to bank erosion. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 consecutive days when flows exceed 2,500 cfs, indicating prolonged high-flow conditions.

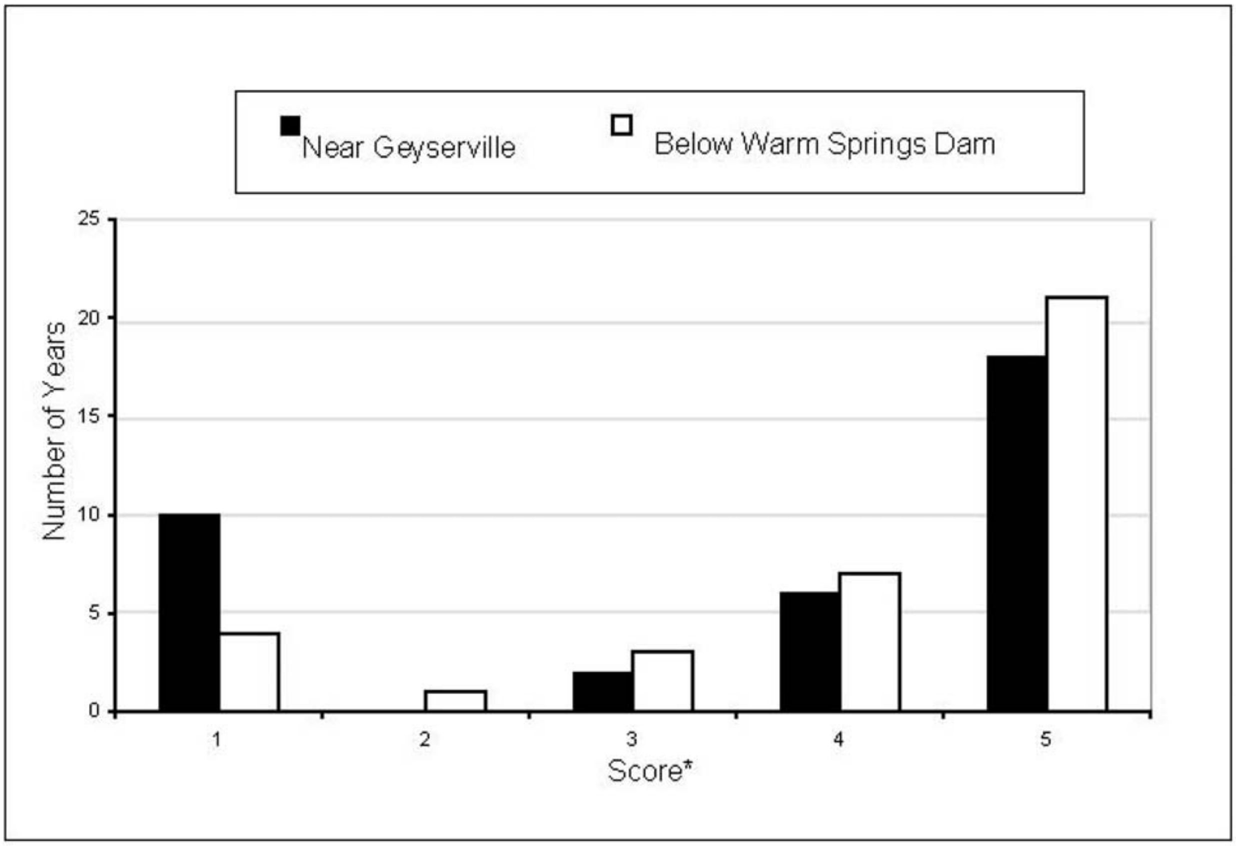
It is noteworthy that on many days when flows exceeded the erosion threshold near Geyserville, discharge from Warm Springs Dam was low (the "Near Geyserville" location is the USGS gaging station downstream of the Pena Creek confluence). For example, inspection of the modeled flow records indicates that in water year 1983, there were 33 days when flows exceeded the 2,500-cfs erosion threshold near Geyserville; but on 13 of those days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Model simulations of the 318 days when flows exceeded the 2,500-cfs erosion threshold show there were 114 days (36 percent of the time) when natural flow accretion below Warm Springs Dam was greater than 2,500 cfs. Flow releases were either very low or smaller than natural flow accretion below the dam so that the erosion threshold would have been exceeded regardless of flood operations at Warm Springs Dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm

Table 5-3 Number of Days with Flow Exceeding 2,500 cfs on Dry Creek, and Score, for 36-Year Period

Water Year	Days Exceeding 2,500 cfs		Score*	
	Below Warm Springs Dam	Near Geyserville	Warm Springs Dam	Near Geyserville
1960	3	3	5	5
1961	0	0	5	5
1962	4	7	4	4
1963	5	6	4	4
1964	0	0	5	5
1965	10	16	3	1
1966	4	4	4	4
1967	9	8	3	3
1968	0	0	5	5
1969	19	18	1	1
1970	26	31	1	1
1971	1	5	5	4
1972	0	0	5	5
1973	7	18	4	1
1974	17	33	1	1
1975	3	7	5	4
1976	0	0	5	5
1977	0	0	5	5
1978	0	6	5	4
1979	0	2	5	5
1980	12	21	2	1
1981	0	0	5	5
1982	7	18	4	1
1983	10	36	3	1
1984	0	3	5	5
1985	0	0	5	5
1986	5	10	4	3
1987	0	0	5	5
1988	0	1	5	5
1989	0	0	5	5
1990	0	0	5	5
1991	0	0	5	5
1992	0	0	5	5
1993	7	25	4	1
1994	0	2	5	5
1995	33	39	1	1

*High scores indicate streamflow conditions were not conducive to bank erosion, while low scores indicate they were.



* Number of years receiving calculated score over the period of record analyzed. Lower scores are indicative of years with relatively greater number of bank erosion events; higher scores indicate relatively fewer bank erosion events for the number of years shown in the graph.

Figure 5-2 Frequency Histogram of the Dry Creek Bank Erosion Scores, 1960 to 1995

Springs Dam on downstream bank erosion. Flood operations at the dam do not cause the prolonged flows above the threshold that initiated streambank instability and erosion in most years.

5.1.2.3 Channel Maintenance and Geomorphology

Flow regulation during flood control operations changes the hydrologic regime, which can cause a geomorphic response. Most channel adjustments, however, likely take place within a few decades after dam construction (Mount 1995).

Adequate flows are periodically needed in a natural channel to maintain channel geomorphic conditions (McBain and Trush 1997). High flows mobilize the streambed and transport sediments, creating bed forms and cleaning fines from the streambed. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids. However, such flows can also scour spawning gravels. Ideally, there is a balance between periodic mobilization of the streambed, sediment transport processes, and stability of spawning gravels. Lack of peak flows can reduce spawning success by increased sedimentation, while frequent peak flows can reduce spawning success through scour.

Land uses and development in the Russian River watershed, including gravel extraction, agricultural practices, and urbanization, have also influenced channel geomorphic conditions (Simons & Associates 1991). Distinguishing the effects of flood control operations from these land-use effects can be problematic.

For instance, on the mainstem Russian River gravel mining operations have altered channel geomorphic conditions between Healdsburg and Ukiah. This has led to almost 16 feet of channel-bed degradation in the East Fork Russian River and approximately 2 feet of bed degradation in the Alexander Valley near Cloverdale (EIP 1993).

Table 5-4 presents scoring criteria based on the number of years in which the maximum flood discharge exceeds the value required to maintain channel geomorphology. A single score is given for the entire period of record (1960 to 1995), because any single year alone does not encompass a sufficiently long time-period to assess whether flood control operations are adequate to maintain channel geomorphic conditions. On average, the natural channel-forming flow should occur in 2 out of every 3 years (Dunne and Leopold 1978). Conditions meeting this criterion (i.e., 19 to 24 times in 36 years) were assigned a score of 5. When the channel-forming flow occurs less frequently, lower scores are applied. Channel-forming flows that occur less than 10 percent of the time (i.e., less frequently than 1 out of every 10 years) receive a score of 1, and if the natural channel-forming flow is never equaled or exceeded, the score is 0. The scoring applies equally to coho salmon, steelhead, and Chinook salmon.

Table 5-4 Scoring Criteria for Maintenance of Channel Geomorphic Conditions

Score*	Annual Flood Exceedance Frequency	Number of Years per 36-Year Period of Record[a]
5	51-66%	19-24
4	36-50%	14-18
3	21-35%	8-13
2	11-20%	5-7
1	1-10%	4 or less
0	0%	0

[a] Multiple channel-forming flows that may occur in a single year are counted as one occurrence for that year.
* Score of 5 is greatest, 1 is least.

Mainstem Russian River

The hydrologic record developed from model simulations for regulated flow conditions using the period 1960-1995 was evaluated to determine the frequency of occurrence of the channel-forming flow. This flow (as an average one-day discharge) was estimated to be 9,500 cfs at Hopland, 14,000 cfs at Cloverdale, and 21,000 cfs at Healdsburg (see Appendix C).

Table 5-5 shows the number of flood events that are predicted to equal or exceed channel-forming flows at each location (years which do not achieve the channel-forming flow are not shown), and the resulting score based on the criteria in Table 5-4. The score is a function of the number of years between 1960 and 1995 that have at least one flood event as an annual maximum that equals or exceeds the channel-forming discharge.

The results show that at Hopland and Cloverdale, at least one channel-forming discharge occurs in 50 percent of the 36 years modeled (18 times out of 36 years). Therefore, a score of 4 is given to these locations, indicating that the flood regime on the Upper Reach Russian River is adequate to maintain channel geomorphic conditions. At Healdsburg, the channel-forming discharge is exceeded in 21 of the 36 years assessed, so this channel region is assigned a score of 5. This reflects the fact that peak flow events at Healdsburg are relatively unaffected by flood control operations at Coyote Valley Dam.

Dry Creek

The hydrologic record developed from model simulations for regulated flow conditions using the period 1960-1995 was evaluated to determine the frequency of occurrence of the channel-forming flow. The channel-forming discharge (as an average daily flow) on Dry Creek was estimated to be 7,000 cfs near Geyserville (below the Pena Creek tributary confluence). Table 5-6 shows the number of simulated flood events that equal or exceed the channel-forming flow (years that do not achieve the channel-forming flow are not shown). Results show 6 years that equal or exceed the channel-forming discharge on Dry Creek. This represents a 17 percent frequency for the 36-year period of record, and therefore the score is 2. This is a low score, indicating that flood control operations have

Table 5-5 Tally of Flow Events Exceeding Channel-Forming Discharge (as Average Daily Flow) and Score for Mainstem Russian River

Water Year	Hopland 9,500 cfs	Cloverdale 14,000 cfs	Healdsburg 21,000 cfs
1960	1	2	2
1962	0	1	3
1963	1	2	2
1965	6	6	5
1966	2	2	1
1967	1	1	1
1969	4	4	2
1970	7	5	7
1971	2	2	3
1973	1	0	3
1974	3	4	5
1975	1	0	1
1978	4	3	5
1980	3	4	5
1982	5	4	6
1983	6	5	9
1984	0	2	1
1986	1	6	7
1991	0	0	1
1993	2	3	3
1995	5	9	9
Number of Water Years with Flow Event that Equals or Exceeds Channel-Forming Discharge	18	18	21
Score*	**4**	**4**	**5**

*Score criteria based on Table 5-4.

Table 5-6 Tally of Flow Events Exceeding Channel-Forming Discharge on Dry Creek

Water Year	Near Geyserville 7,000 cfs
1970	4
1971	1
1973	1
1974	2
1978	1
1980	2
Number of Water Years with Flow Event that Equals or Exceeds Channel-Forming Discharge	6
Score*	**2**

*Score criteria based on Table 5-4.

reduced the frequency of channel-forming flows in Dry Creek and may not be adequate to maintain overall channel geomorphic conditions as represented by the historic channel form.

Immediately below Warm Springs Dam, the channel-forming discharge (as an average daily flow) is 5,000 cfs. There were no simulated flows over the period of record that equaled or exceeded the channel-forming discharge. Therefore, the score for the channel reach between the dam and Pena Creek is 0, indicating potentially inadequate channel maintenance flow associated with the historic pre-dam channel morphology of Dry Creek.

Despite the lack of pre-dam geomorphic flows, the spawning gravels in Dry Creek appear to be suitable for use by coho salmon, steelhead, and Chinook salmon. No evidence of excessive sedimentation that would inhibit incubation success has been noted, and successful spawning by Chinook salmon and steelhead have been reported.

As noted in Section 2, Dry Creek has undergone some geomorphic change as a result of the construction of Warm Springs Dam, agricultural practices, and gravel mining. Significant channel geomorphic changes were apparently already underway on Dry Creek prior to the construction of Warm Springs Dam. USACE conducted a study that concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that it was unlikely that further channel degradation would occur, but that continued lateral instability and erosion of the incised channel banks were likely.

Downstream of Warm Springs Dam, channel geomorphology has already changed substantially, not only in response to flow regulation associated with the dam, but to historic pre-dam gravel mining and other land-use activities in the watershed. It is likely continuing to adjust towards a new equilibrium. With a narrower, incised low-flow channel, and vegetation encroachment, the pre-dam channel-forming flows may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek are still sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed.

5.1.2.4 Effects of Ramping Rates during Flood Control Operations on Listed Fish Species

Ramping rates refer to the rate of change in water releases from flood control reservoirs into mainstem channels. These rates are an important component of flood control operations, because salmonids can become stranded in downstream channels if flows recede too quickly.

The analysis of ramping rates on the Russian River assumes the effect of ramping at the dams is attenuated approximately 5 miles downstream of Coyote Valley Dam past the confluence with the mainstem Russian River at the Forks, and 1.0 to 1.5 miles downstream of Warm Springs Dam in Dry Creek to near the Pena Creek confluence. The evaluation assesses whether the rates of stage change during ramping operations pose a risk to young salmonids. The evaluation criteria were based on the ramping-rate guidelines developed by Hunter (1992) and the interim ramping criteria developed in consultation with CDFG. The Hunter (1992) guidelines are considered a conservative ramping standard for the Russian River watershed because they were developed on streams located in the Pacific northwest, a hydrologic regime that is dominated by snowmelt processes. In the Russian River drainage, storms naturally result in “flashy” runoff conditions with relatively larger changes in stage compared with snowmelt runoff conditions. The evaluation criteria are discussed further in Appendix C.

Coyote Valley Dam

Hourly flow-release data at Coyote Valley Dam were inspected for 1997 to 1999. Typically, ramping rates were approximately 250 cfs/hr for flows between 1,000 cfs to 250 cfs and only infrequently exceeded this ramping rate. For flows below 250 cfs, ramping rates were generally below 125 cfs/hr and rarely exceeded this rate. Based on the ramping scoring criteria, flood control operations received a score of 4 or better, when a stage change criterion of 0.32 ft/hr was met. On the mainstem Russian River, the ramping performance was evaluated at four cross-sections, located between 3 miles downstream of Coyote Valley Dam and 5 miles below the dam, near the Perkins Street Bridge crossing in Ukiah. There are no existing cross-section surveys further upstream or on the East Fork Russian River. Using a ramping rate of 250 cfs/hr, none of the cross-sectional areas achieved a stage change of less than 0.32 ft/hr (i.e., 100 percent greater than the Hunter criteria). In fact, stage changes were generally 0.5 ft/hr or more, suggesting there is a potential risk of stranding fish in the Upper Russian River mainstem.

Based on these results, a score of 3 was assigned to ramping operations during reservoir releases in the range of 1,000 to 250 cfs (Table 5-7). This score is applicable to steelhead fry and juvenile life-history stages. Chinook salmon and coho salmon do not generally rear in the East Fork.

Table 5-7 Coyote Valley Dam Ramping Scores for High-Reservoir Outflows (1,000 to 250 cfs) during Flood Control Operations

Scoring Category	Criteria	Score
5	Meets 0.16 ft/hr maximum stage change.	
4	Within 100% of 0.16 ft/hr criterion (0.32 ft/hr) for stage change.	
3	Meets interim ramping criterion (250 cfs/hr).	X
2	Exceeds interim ramping criteria up to 50% (375 cfs/hr).	
1	Exceeds interim ramping criteria by greater than 50% (>375 cfs/hr).	

Warm Springs Dam

Stage-discharge relationships generated by the HEC-RAS model (*Interim Report 1,* ENTRIX, Inc. 2000a) were used to evaluate potential ramping effects on salmonids in Dry Creek. Hourly flow-release data were also examined to determine the extent to which reductions in flood control releases occurred within ramping guidelines. Ramping scores are shown in Table 5-8.

Table 5-8 Dry Creek Ramping Scores for High-Reservoir Outflows (1,000 cfs to 250 cfs)

Scoring Category	Criteria	Score
5	Meets 0.16 ft/hr maximum stage change.	
4	Within 100% of 0.16 ft/hr criterion (0.32 ft/hr) for stage change.	
3	Meets 250 cfs/hr ramping criterion.	X
2	Exceeds 250 cfs/hr ramping criteria up to 50% (375 cfs/hr).	
1	Exceeds 250 cfs/hr ramping criteria by greater than 50% (>375 cfs/hr).	

Hourly flow-release data at Warm Springs Dam were inspected for 1997 to 1999. Typically, ramping rates were within 250 cfs/hr for flows between 1,000 cfs to 250 cfs, and only rarely exceeded this ramping rate. Flood control operations receive a score of at least 3. Stage changes during ramping-down were measured at ten cross-sectional areas from Warm Springs Dam to 1.5-mile downstream on Dry Creek. Stage changes associated with a 250-cfs/hr ramping rate exceeded 0.16 ft/hr at all ten cross-sections. HEC-RAS model results indicate that stage changes range from 0.20 to 0.80 ft/hr. The greatest change in stage during ramping always occurred when release flows were low (i.e., between 500 cfs and 250 cfs).

Of the ten cross sections, the four furthest downstream (HEC-RAS model numbers 103 to 106 [*Interim Report 1,* ENTRIX, Inc. 2000a]) generally met the 100-percent stage-change criteria for juveniles (i.e., 0.32 ft/hr), which would merit a score of 4. However, the remaining six cross-sections closest to Warm Springs Dam did not meet the 0.32 ft/hr evaluation criteria. Thus, ramping-down of flow releases in this range pose a low but acceptable risk of stranding for coho salmon, steelhead, and Chinook salmon. Therefore, a final score of 3 is assigned for ramping during reservoir releases in the range of 1,000 cfs to 250 cfs (Table 5-8). This score is applicable to both fry and juvenile lifestages for all three listed fish species.

<u>Ramping Rates for Releases Less Than 250 cfs</u>

The following paragraphs consider ramping rates for flow releases less than 250 cfs for both Coyote Valley Dam and Warm Springs Dam. Evaluation criteria are scored for ramping practices at both dams for periods when fry (salmonids less than 50 mm) are present and when juveniles only are present. Table 5-9 shows the periods when fry may be present for each species. Evaluation criteria are applicable for all three listed fish species in the Russian River and in Dry Creek, as rearing and migration could potentially be affected.

Table 5-9 Times When Fry May Be Present in the Russian River Drainage

Species	Emergence	Fry May Be Present
Coho	Feb. 1 - Mar. 31	Feb. - April
Steelhead	Mar. 1 - May 31	Mar. - June
Chinook	Feb. 1 - Mar. 31	Feb. - April

Under the proposed project, flow ramping rates would be 25 cfs/hr or less at both Coyote Valley and Warm Springs dams when releases are less than 250 cfs.

East Fork and Mainstem Russian River below Coyote Valley Dam

Ramping rates are of particular concern in the mainstem during periods when flows are low, as there is less attenuation of flow recessions. In *Interim Report 1* (ENTRIX, Inc. 2000a), stage changes associated with 25 cfs/hr incremental flow reductions were modeled at four cross-sections in the mainstem from approximately 3 miles below Coyote Valley Dam to 5 miles below the dam near the Perkins Street Bridge crossing in Ukiah. (There are no existing cross-section surveys further upstream or on the East Fork Russian River.) These stage changes were modeled beginning at 250 cfs and progressing to 50 cfs.

At 25 cfs/hr reductions, the 0.16 ft/hr Hunter criterion (1992) is met at most flow intervals in all four of the cross-sections for flow ranges below 250 cfs. Stage changes ranged from 0.04 to 0.36 ft/hr. Therefore, a ramping rate of 25 cfs/hr when flows are below 250 cfs would be protective of young salmonids. A score of 4 is given when only juveniles are present and a score of 3 is given when fry are present (Table 5-10).

At Warm Springs Dam, flows are ramped at a rate of 25 cfs/hr, and a score of 4 is given for the period when only juveniles are present (Table 5-10). The score is 3 when fry are present.

Table 5-10 Evaluation Criteria for Low-Reservoir Outflows (250 cfs to 0 cfs) during Dam Maintenance and Pre-Flood Inspection Periods

Score* Juvenile	Score* Fry	Change in Flow (cfs/hr)	Operations Score
5	5	0-10	
5	4	10-20	
4	3	20-30	Warm Springs Dam Coyote Valley Dam
3	2	30-40	
2	1	40-50	
1	0	>50	

Note: These scores are applicable when ramping takes place during periods when flows are less than 500 cfs at the Ukiah gage.
* A score of 5 indicates lowest ramping rate and 1 indicates highest.

5.1.3 Annual and Periodic Dam Inspection and Maintenance

During dam inspection, maintenance activities, or changes in hydroelectric operations, releases from the dams are ramped-down or stopped altogether. These activities occur during summer or fall when salmonid fry are present, which are more susceptible to stranding than larger fish. The issues of concern for dam inspection and maintenance activities are bypass flows, and timing of inspection and maintenance activities.

5.1.3.1 Russian River

Flow interruption during dam inspections for 2 or more hours could pose a threat to young salmonids in the East Fork Russian River. Under the proposed project, a bypass flow of 25 cfs would be released from Coyote Valley Dam via the proposed bypass pump system. This would prevent dewatering, reduce the risk of stranding juveniles, and maintain rearing habitat in the East Fork and mainstem Russian River below the Forks, where stranding has been observed in the past.

At Coyote Valley Dam, fish rescue of juvenile steelhead was necessary on the East Fork and further downstream on the mainstem Russian River during inspection and maintenance activities in September 1998. However, in June 1999 when releases were near 0 cfs, no stranding of salmonids was documented. Habitat adequate to support fry and juvenile fish may have been maintained by dewatering the stilling basin, which provided up to 5 cfs for several hours following cessation of releases from the dam, and by flow accretion from seepage or groundwater contributions. Approximately 5 to 6 cfs has been measured at the weir after flows have ceased from Coyote Valley Dam (USACE 2003c). Very little to no mortality of federally listed species has been observed over the past 5 years during monitoring for inspection and maintenance activities when these activities have been scheduled for September (USACE 2003c). Inspections scheduled in the spring have resulted in a greater incidental take because of the smaller size and poorer swimming ability of younger fish (USACE 2003c).

Under the proposed project, bypass flows in the East Fork will be 25 cfs while maintenance and inspection activities are being conducted in the summer or fall.

5.1.3.2 Dry Creek

Because there is a bypass flow capability at Warm Springs Dam, dewatering is unlikely. Juvenile fish stranding has not been documented during recent inspection and maintenance activities.

Under the proposed program, the annual and periodic inspection and maintenance activities will be scheduled between July 15 and October 15. This would avoid periods when fry are present, and would occur after the smolts have migrated out.

5.1.4 HYDROELECTRIC FACILITIES AT WARM SPRINGS DAM

Hydroelectric facilities at Warm Springs Dam generate power from releases from Lake Sonoma. *Interim Report 7* (ENTRIX, Inc. 2000b) evaluated potential effects of hydroelectric operations on listed fish species. Under the Flow Proposal, the hydroelectric project will not be able to operate year-round. At flow releases of less than 75 cfs, the hydroelectric project is not operational. The effects on listed fish species when the hydroelectric operations are operating would be similar to those under baseline project operation. These effects that were evaluated in greater detail in *Interim Report 7* are summarized below.

Hydroelectric operations are incidental to water supply and flood control operations and therefore have no effect on streamflow or water temperature downstream of Warm Springs Dam. All maintenance activities occur within the Warm Springs Dam control structure shaft. During any unplanned events that require shutting down the generator, automatic controls shut down flows to the turbine and open a valve that bypasses flows around the turbine unit. Therefore, maintenance activities would not affect flows to Dry Creek and would not affect listed fish species.

The potential for the hydroelectric operation to result in dissolved gas supersaturation was evaluated as a potential effect on listed fish species. Gas supersaturation, especially nitrogen, below other hydroelectric facilities, has been known to cause gas bubble disease in juvenile and adult fish (Ebel and Raymond 1976). Dissolved gas supersaturation can be caused by the entrainment of air bubbles in the water under pressure.

Many causes of dissolved gas supersaturation in other river basins are not at work in the Russian River. There have been no reports of stress or mortality in fish directly below Warm Springs Dam. Dissolved gas levels have been measured at the inlet to the DCFH directly below the dam and data show gas levels at saturation (R. Gunter, CDFG, pers. comm. 2000a). If saturation levels of nitrogen were to increase, they would be expected to be restored to air saturation levels by turbulence in the discharge channels of the dam and in riffles and runs downstream of the facility. There are no indications that operations of the hydroelectric facilities at Warm Springs Dam bring gas supersaturation to a harmful level for listed fish species.

5.2 DIVERSION FACILITIES AND WATER SUPPLY AND TRANSMISSION SYSTEM

The operation and maintenance of the inflatable rubber dam at Mirabel and the Mirabel and Wohler diversion facilities could have effects on salmonids and their habitat, as follows.

Potential Direct Effects on Listed Species

- Passage of adult and juvenile salmonids past project facilities (dam and diversions), and potential migration delays.
- Entrainment into diversion ponds when stormflows overtop levees.
- Stranding potential from dam inflation and deflation.
- Injury to listed species from maintenance activities.

Potential to Alter Habitat

- Instream flow effects on habitat (addressed in Section 5.3).
- Alteration of habitat in Wohler Pool.
- Alteration of habitat from operation and maintenance activities.
- Water quality effects from accidental releases of chemical additives and facility maintenance substances.

Potential Indirect Effects

- Increase in predation risk from maintenance and operation activities.

In Section 5.2.1, fish passage in the following locations is evaluated: 1) past the inflatable dam, 2) past the Mirabel and Wohler screened diversions during both low-flow and high-flow seasons, and 3) through the impoundment (Wohler Pool) created by the inflatable dam. The potential to strand fish when the dam is inflated or deflated is evaluated in Section 5.2.2. In Section 5.2.3, Wohler Pool is evaluated for alteration of riverine habitat and its potential to create habitat for a warmwater fish community that could prey on salmonids. Finally, potential direct and indirect effects of operation and maintenance activities and water treatment facilities are evaluated.

5.2.1 FISH PASSAGE

The potential direct and indirect effects of the inflatable dam and the Mirabel and Wohler facilities on salmonid fish passage are considered. This section begins with an evaluation of adult salmonid migration through the fish ladders at the inflatable dam. This is followed by an evaluation of fish passage past the diversion facilities. Finally, juvenile fish passage through Wohler Pool is evaluated.

5.2.1.1 Fish Passage Past the Inflatable Dam

Fish Ladders

Adult upstream passage conditions past the inflatable dam are evaluated based on the effectiveness of the fish ladders installed at both sides of the dam. The evaluation is based on the design of the fish ladders compared to published criteria, results of a SCWA video monitoring study, and whether sufficient attraction flows are provided through the ladders. Additionally, the effects of a bypass pipeline at the dam are evaluated.

Two Denil-style fish ladders provide upstream passage for adult spawners when the inflatable dam is in operation. The inflatable dam is generally raised in April or May and deflated in November or December (Table 5-12). However, the dam could be raised and/or deflated earlier or later in the year, depending on weather and water demand.

The fish ladders generally operate at the beginning of the adult coho salmon upstream migration period and during the peak adult Chinook salmon migration period. The dam is not usually inflated during peak steelhead spawning migration because flows are generally too high (Table 5-11).

Table 5-11 Average Number of Days per Month that the Dam was Inflated, 1999 through 2002, and Adult Salmonid Upstream Migration Periods

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
Frequency	6	27	30	31	31	30	31	23	10	2	0	0
Adult Upstream Migration Period												
Coho												
Steelhead												
Chinook[1]												

[1] Under the proposed project, the sandbar would generally not be breached before mid-October, so Chinook salmon would not enter the river prematurely.

The design drawings of the Denil-style fish ladders show they are built within the guidelines of published criteria (see Appendix C). The fish ladders have approximate slopes of 1 foot of rise to 8 feet of run. Turning pools are located in each fishway to provide temporary, in-transit, and resting areas. Baffle sections provide less turbulent water on the bottom of each fishway. Sufficient water is provided to achieve fish attraction flows. The fishways are equipped with a trash rack to prevent clogging or damage due to debris.

A time-lapse (one image every 0.2 second) video monitoring system has been deployed at the upstream end of each fish ladder during the salmonid upstream migration periods when the dam has been inflated from 1999 to the present. Videotapes were reviewed on high quality VCRs with slow motion and freeze frame capabilities. Image quality was generally good to excellent, although turbidity occasionally made it difficult to collect data. When a fish was observed, tapes were reviewed frame by frame to determine the species and direction (upstream or downstream) of the fish. Data on adult migration through the ladder indicate salmonids can locate the fish ladders and pass successfully (Winzler and Kelly 1978; Chase et al. 2000, 2001, 2002). Even less powerful swimmers, such as Pacific lamprey, were documented to use the ladders successfully.

Snorkeling surveys were conducted below the inflatable dam every 2 to 3 weeks during the summer of 1999 to examine the possibility that adult salmon were holding below the dam before entering the ladders. If significant numbers of fish were found below the dam, there could be a delay in migration through the ladders. Although the video data are described as having "limited usefulness" because of limited visibility, no adult salmonids were observed (Chase et al. 2000), indicating no migration delay.

Table 5-12 shows the adult fish passage scores based on the risk the fish ladder design and operation poses to upstream migration. The fish ladder design is within the guidelines of published criteria. Video monitoring also confirms all adult species of salmonids appear to pass the inflatable dam without difficulty. The dam is generally not inflated during peak steelhead spawning migrations, but field data show that, when steelhead use the fish ladder, they pass successfully. Therefore, the adult upstream passage score for the inflatable dam is 5 for all three species.

Table 5-12 Adult Fish Passage Scores by Species at the Inflatable Dam – Fish Ladder Design and Operation

Category Score	Evaluation Categories	Current Operations Score*
5	Fish ladder passes adult salmon without delay.	Co, Ch, St
4	Fish ladder passes adult salmonids with acceptable delay.	
3	Fish ladder passes all target species after extended delay.	
2	Fish passage does not pass all target species of adult salmonids.	
1	Fish passage provided, but does not appear to pass any adult salmonids; or passage not provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Attraction Flows

Adult salmonid passage is also affected by attraction flows from the fish passage facility (fish ladder and bypass outfall). Insufficient attraction flows could make it difficult for adult fish to find the entrance to the fish ladder, thereby creating migration delays. If the amount of water provided for the fish ladder and bypass system is at least 10 percent of the total flow, attraction flow is sufficient to attract adults into the ladder entrance.

Interim Report 4 (ENTRIX Inc. 2001d) evaluated the amount of time that attraction flow would meet the 10 percent criterion under baseline flow and demand conditions. A

Russian River hydrologic simulation model was used to estimate streamflow at the dam during the months it was normally raised (late May through early November) over 35 water years (1960 to 1995). The amount of water diverted to the infiltration ponds or through the fish ladders and bypass facility was subtracted to estimate total streamflow at the dam. The simulations were used to predict how often flows passing through the fish passage facility would be less than 10 percent of total river flow.

Of the 35 water years evaluated, fish ladder flows were less than 10 percent of total river flow for approximately 11.5 days per year during dam inflation. Attraction flows below the desired 10 percent of streamflow generally occurred during high-flow storm events, when more water goes over the dam and therefore less than 10 percent of the flow is channeled through the fish passage facility. The daily data indicated that nearly all high-flow events in the river occurred when the dam was in operation late in the year (i.e., late October or early November), although a few events occurred early in the year as a result of late spring storms. The daily data showed that the duration of a high-water event that would affect attraction flows is normally short (i.e., 2 to 3 days).

In general, attraction flows under the proposed project would be sufficient to provide unrestricted passage for all three species of threatened salmonids. Storm events might still create temporary flows through the ladder of less than 10 percent of total flow. During the low-flow portion of the spawning season (late summer and early fall), all flow would go through the ladders or the bypass pipes. Therefore, implementation of the Flow Proposal would not increase the number of times attraction flows failed to meet the 10 percent criterion.

Bypass Pipeline

The bypass pipeline at the east side of the dam produces turbulent flow at the downstream entrance of the east-side fish ladder, which may impede passage. In 1999, flows through this bypass pipeline were decreased, resulting in decreased turbulence and enhanced functioning of the fish ladder. During the following 3 years, approximately 47 percent of the Chinook salmon counted during SCWA's video monitoring moved through the east-side fish ladder, which suggests the ladder functions effectively (S. Chase, SCWA, pers. comm. 2003a). If future monitoring suggests it is needed, SCWA would modify the east-side bypass pipeline to operate at its full 22-cfs capacity. Therefore, fish passage will not be delayed at the ladder on the eastern side of the dam. The west-side bypass line and fish ladder function properly.

Overall, adults of all three listed salmonid species pass through the fish ladder easily and without delay. Based on video monitoring in the ladders at Mirabel, it is evident that adults of all three listed species are able to locate the fish ladders and pass the inflatable dam (Chase et al. 2000, 2001, and 2002). Relatively large numbers of adult Chinook salmon and steelhead have been documented negotiating the ladders and large numbers of fish milling at the base of the dam have not been observed. Ladder design and operation conforms to published criteria for fish ladders. Sufficient attraction flows occur most of the time, and periods when the attraction flow criterion is not met are infrequent and of short duration.

5.2.1.2 Fish Passage Past Wohler Diversion

Many of the negative effects associated with water diversion facilities described in Section 3 are addressed in the proposed project. The proposed project minimizes the potential to impinge fry and juvenile salmonids by upgrading the fish screens at the diversion facilities to meet current NOAA Fisheries criteria.

During storm flows, levees at the infiltration ponds occasionally overtop, and listed fish species may be entrained. Under the proposed project, the infiltration ponds would be graded to minimize the risk of entrainment and a continual connection would be maintained from the Wohler ponds to the river during the high-flow season.

Fish Screens

The two Wohler ponds are operated independently and are filled by independent intake canals. New fish screens would be placed in permanent concrete intake structures at the terminus (river end) of each canal. The screens will consist of wedge-wire construction with 1.75-mm maximum-width slots and 50 percent open area. Each screen will be equipped with a mechanical cleaning mechanism. Because of the screen location at the ends of the canals, sweeping flows cannot be provided. However, the screened area will be large enough to minimize approach velocities at the screen face. Approach velocities will be regulated through manipulation of a slide gate.

Table 5-13 shows the criteria scores assigned to fish passage past the Wohler canal diversion. The screens will be designed to operate within NOAA Fisheries fish screen criteria for juveniles and fry. Therefore, the risk is low and the score is 5 for both juvenile and fry of all three species.

Table 5-13 Passage Scores for Fry and Juvenile Salmonids – Screen Design and Operation for the Wohler Canal Screens

Category Score	Evaluation Categories	Operations Score*
5	Fish screens meet NOAA Fisheries criteria and pass fish without injury or delay.	Co, St, Ch
4	Facility provided with fish screens, but the facility has a low risk of entrainment, impingement, or migration delay.	
3	Facility provided with fish screens, but the facility has a moderate risk of entrainment, impingement, or migration delay; effective rescue or escape is provided.	
2	Facility provided with fish screens, but the facility has a high risk of entrainment, impingement, or migration delay; ineffective rescue or escape is provided.	
1	Facility not provided with fish screens; no rescue or escape is provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Wohler Infiltration Ponds

The infiltration ponds occasionally flood during storm events. The ponds are isolated from the river by levees; when floods overtop the levees, salmonids (and potential predators) may be trapped in the ponds as water levels recede. This may subject salmonids to increased risk of injury, predation, and migration delays.

The potential effects on salmonids are evaluated based on the opportunity for entrainment, injury, or migration delays. The first component of the evaluation looks at the frequency of pond flooding within a year and the time of year the ponds are flooded (compared to salmonid migration periods). The second component addresses the risk of entrapment based on amount of water diverted into the ponds. SCWA fish rescue data are also examined to evaluate this risk. These components of the evaluation are then synthesized to evaluate the overall risk. Finally, recent modifications to the Wohler ponds and how they reduce this risk are discussed.

For the first component, pond flooding frequency and time of year, Table 5-14 provides estimates for the number of days the Wohler ponds would have overtopped over a 35-year period (1960 through 1995), based on results from computer simulations, and compares them to salmonid migration periods. The probability that the ponds would overtop in any day in a month is also listed. The model predicts that Wohler Pond 1 would have overtopped 533 days over the 35-year period and Wohler Pond 2 would have overtopped 625 days. Pond 1 would have flooded in 30 of the total 35 years and Pond 2 would have flooded in 31 years (Table 5-15). In general, overtopping is predicted to occur between November and April, which overlaps with the smolt outmigration period and adult upstream migration period of all three species. The highest probabilities of overtopping occur in January and February.

The probability that the ponds would overtop in any one day during a species' migration period was calculated by summing the number of days the ponds are predicted to overtop during the migration period and dividing by the total number of days in the migration period over a 35-year period. (This assumes overtopping events are independent and not cumulative.) For coho salmon downstream migration, that probability is 0.085 in Wohler Pond 1 and 0.102 in Wohler Pond 2. For the Chinook salmon migration period, the probabilities are lower, at 0.050 and 0.060 for Wohler Ponds 1 and 2, respectively. For steelhead, it is even lower, at 0.030 and 0.037, respectively. Therefore, there is a moderate risk of entrainment. The risk is highest for coho salmon because a greater proportion of the downstream migration period overlaps overtopping events.

The second component of the evaluation looks at the risk of entrapment based on the amount of water diverted into the ponds. Although the portion of the mainstem flows that enters the pond during flooding has not been measured, it is estimated at less than 5 percent, as the Wohler ponds are relatively small (1.4 acres). Because less than an estimated 5 percent of the flood streamflow enters the Wohler ponds, this component of the risk is low.

This analysis is consistent with data collected during fish rescue efforts in the infiltration ponds (Table 5-16) (SCWA 1998b, 1999c, 2000d). Fish rescue efforts at the Wohler ponds in 1998 and 1999 found only steelhead. Some Chinook salmon juveniles were rescued in 2000. Year-to-year variation in migration periods and storm events, or increases in coho salmon abundance, could result in the entrapment of coho salmon in future years.

A total of 79 juvenile hatchery steelhead (out of 850 fish of all species) were captured in 1998 during rescue efforts at the Wohler ponds. The steelhead captures in 1998 correlated with large releases of hatchery steelhead. Of these, 13 hatchery steelhead died during seining. In 1999, 29 hatchery steelhead and 32 naturally-spawned steelhead were rescued

Table 5-14 Total Number of Days per Month that Wohler Ponds 1 and 2 were Overtopped, 1960 through 1995 (Computer Simulation), and Probability of Overtopping During Months in Migration Periods

Wohler Pond 1												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Days per 35 Years[1]	169	135	100	30	0	0	0	0	0	0	25	74
Probability per Day	0.156	0.138	0.092	0.029	0.000	0.000	0.000	0.000	0.000	0.000	0.024	0.068
Wohler Pond 2												
Month	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Days per 35 Years	188	161	120	36	0	0	0	0	0	2	28	90
Probability per Day	0.173	0.164	0.111	0.034	0.000	0.000	0.000	0.000	0.000	0.000	0.027	0.083
Juvenile Emigration Periods												
Coho												
Steelhead												
Chinook												
Adult Upstream Migration Periods												
Coho												
Steelhead												
Chinook[2]												

[1] The total days the ponds could potentially overtop is 35 years x 120 days/year = 4,200 days.

[2] Under the proposed project, the sandbar would generally not be breached before mid-October, so Chinook salmon would not enter the river prematurely.

Table 5-15 Number of Days by Water Year that the Wohler Ponds Would Have Overtopped, 1960 through 1995 (Computer Simulation)

Wohler Pond 1		Wohler Pond 2	
Water Year	Number of Days Exceeded[1]	Water Year	Number of Days Exceeded[1]
WY 1960	10	WY 1960	11
WY 1961	7	WY 1961	11
WY 1962	15	WY 1962	17
WY 1963	20	WY 1963	28
WY 1964	3	WY 1964	4
WY 1965	23	WY 1965	25
WY 1966	10	WY 1966	14
WY 1967	21	WY 1967	22
WY 1968	7	WY 1968	8
WY 1969	35	WY 1969	43
WY 1970	32	WY 1970	34
WY 1971	16	WY 1971	21
WY 1972	0	WY 1972	0
WY 1973	30	WY 1973	32
WY 1974	35	WY 1974	38
WY 1975	17	WY 1975	21
WY 1976	0	WY 1976	0
WY 1977	0	WY 1977	0
WY 1978	30	WY 1978	31
WY 1979	7	WY 1979	9
WY 1980	25	WY 1980	28
WY 1981	6	WY 1981	6
WY 1982	36	WY 1982	42
WY 1983	63	WY 1983	71
WY 1984	20	WY 1984	21
WY 1985	3	WY 1985	4
WY 1986	28	WY 1986	30
WY 1987	2	WY 1987	3
WY 1988	3	WY 1988	6
WY 1989	1	WY 1989	4
WY 1990	0	WY 1990	0
WY 1991	2	WY 1991	5
WY 1992	0	WY 1992	2
WY 1993	7	WY 1993	10
WY 1994	0	WY 1994	0
WY 1995	19	WY 1995	24

[1] Number of days flows were high enough that the pond levees were predicted to overtop.

Table 5-16 Summary of Salmonids Captured in the Mirabel and Wohler Infiltration Ponds during Fish Rescue Efforts

	Chinook			Steelhead (Wild)			Steelhead (Hatchery)		
	1998	**1999**	**2000**	**1998**	**1999**	**2000**	**1998**	**1999**	**2000**
Pond Number[2]									
Mirabel Pond 1	6			0			0		
Mirabel Pond 2	2			0			0		
Mirabel Pond 3	1/1[1]			0			0		
Mirabel Pond 4	1/1[1]			0			0		
Sedimentation Pond	0			0			0		
Wohler Pond 1	0	0	1	0	17	2	50	29	9
Wohler Pond 2	0	0	8	0	15	66	16/13[1]	0	0
Total	**12**	**0**	**9**	**0**	**32**	**68**	**79**	**29**	**9**

[1] Two numbers indicate number rescued/number of mortalities.
[2] In 1998, there was one rescue event in the Mirabel ponds, but none in 1999 or 2000. In 1998 and 1999, there were two rescue events in the Wohler Ponds each year; in 2000, there were two in Wohler Pond 1 and four in Wohler Pond 2.

from the Wohler ponds, out of a total of 539 fish. One adult steelhead mortality was found in the outlet culvert at Wohler Pond 2 in March 1999, and one unmarked (not hatchery marked) adult steelhead was rescued in March 1999. In 2000, 84 juvenile salmonids were returned to the river and 2 died.

Integrating these components of the evaluation, less than 5 percent of streamflow during flood events enters the Wohler ponds, and the ponds can overtop during a small portion of the migration periods of all three species. This could pose a small risk to downstream migration of juveniles. Fish rescue data from past years demonstrate that salmonids are occasionally entrained.

However, modifications at the Wohler ponds are likely to reduce this risk to a very low level. The Wohler ponds would be regraded to direct fish towards the inlet/outlet pipe, significantly reducing the potential for entrapment and minimizing the need for fish rescue operations. (The fish screens would not be in place during the high-flow events.) Because an effective, continual connection would be maintained between the pond and the river, fish would be able to return to the river at will, and the overall risk of injury or mortality would be reduced to a very low level. By providing an area of refuge from high-flow events in the river, this connection may benefit some salmonids. Fish rescue operations would be conducted, if needed, when water levels recede.

5.2.1.3 Downstream Fish Passage Past Mirabel Diversion

As with the Wohler diversion, the effects of the Mirabel diversion on salmonid migration are assessed by evaluating the fish screen design and operation and the opportunity for fish to be impinged or injured at the facility fish screens. Proposed modifications to the fish screens are evaluated.

The risk of entrainment is also evaluated for occurrences of pond levees overtopping during the high-flow season. Proposed actions designed to minimize this risk are evaluated.

Fish Screens

Under baseline conditions, the fish screens at the Mirabel diversion facility meet most NOAA Fisheries criteria for juveniles, but not for fry. Table 5-17 summarizes the design criteria for the proposed project changes in screen design and the NOAA Fisheries criteria for fry and juveniles. Several NOAA Fisheries criteria for fish screens are more stringent for fry than for juveniles. For example, they specify that approach velocities cannot exceed 0.33 fps, that a perforated plate-screen opening cannot exceed 3/32 inches in diameter, and that a minimum of 27 percent of open area on the screen is required for fry.

The proposed design meets, or exceeds, the NOAA Fisheries criteria for both fry and juveniles (Table 5-17). The screen area is approximately 25 percent greater than the size required to meet the 0.33-fps approach velocity criterion. The additional area is provided to allow for variation in operating parameters.

Table 5-17 Critical Operating Parameters for Proposed Mirabel Fish Screens

Parameter	Mirabel Fish Screens	NOAA Fisheries Juvenile Criteria	NOAA Fisheries Fry Criteria
Net equivalent submerged screen area	450 square feet		
Screen open area	50%	40% open area	27% open area
Approach velocity	≤ 0.33 fps	≤ 0.8 fps	≤ 0.33 fps
Sweeping velocity	Upstream: 2.0 fps Downstream: 1.33 fps	Greater than approach velocity (sufficient to sweep debris away from screen face)	Greater than approach velocity (sufficient to sweep debris away from screen face)
Screen opening size	1.75 mm slot width	≤ 8/32 inches	≤ 1.75 mm slot width

With the current design, smolts tend not to use the fish ladder for downstream migration. Under the proposed project, the upstream portion of the fish ladder would be redesigned. Integration of the intake structure with the top of the fish ladder would improve passage conditions for fry and juvenile salmonids past the diversion facility.

Other critical operating parameters meet the NOAA Fisheries criteria for juvenile salmonids. A traveling vertical brush would keep the screens free of silt and other debris, and a trash rack would be installed on the ends of the intake structure. Due to location and a consistent pool elevation, hydrologic conditions at the screens have little variability so diversion operations should remain relatively consistent. Because the Mirabel pumped diversion screen design and operation would be consistent with NOAA Fisheries criteria, juveniles and fry of the three salmonid species would safely migrate down the river past the screened diversion. Therefore, the score for screen design and diversion passage is 5 (Table 5-18).

Table 5-18 Passage Scores for Fry and Juvenile Salmonids – Screen Design and Operation for the Mirabel Pump Diversion

Category Score	Evaluation Categories	Operations Score
5	Fish screens meet NOAA Fisheries criteria and pass fish without injury or delay.	Co, St, Ch
4	Facility provided with fish screens, but the facility has a low risk of entrainment, impingement, or migration delay.	
3	Facility provided with fish screens, but the facility has a moderate risk of entrainment, impingement, or migration delay; effective rescue or escape is provided.	
2	Facility provided with fish screens, but the facility has a high risk of entrainment, impingement, or migration delay; ineffective rescue or escape is provided.	
1	Facility not provided with fish screens; no rescue or escape is provided.	

* Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Mirabel Infiltration Ponds

The infiltration ponds at Mirabel are less likely to flood during storm events than the ponds at Wohler. Salmonids may be subjected to a risk of entrainment, injury, predation, and migration delays during high-flow events.

Table 5-19 provides estimates for the number of days the Mirabel ponds would have overtopped over a 35-year period (1960 through 1995), based on results from computer simulations, and compares them to salmonid migration periods. The probability that the ponds would overtop in any day in a month is also listed. The model predicts that the Mirabel ponds would have overtopped 32 days over the 35-year period and at least once in 15 of the 35 years, and flooded only 14 days during this time period (the ponds could overtop for more than one day during a single flood event) (Table 5-20).

The ponds are predicted to overtop only during December through March. Based on the probability of overtopping in any one day in the month, the risk would be highest in January (Table 5-19).

The probability that the ponds would overtop in any one day during a species migration period was calculated by summing the number of days the ponds are predicted to overtop during the migration period and dividing by the total number of days in the migration period over a 35-year period. For coho salmon downstream migration, that probability is 4.1×10^{-6} and for Chinook salmon it is 2.5×10^{-6}. For steelhead, it is even lower, at 8.6×10^{-7}. Fry-rearing periods also have some overlap. Thus, during the migration periods of all three species, the ponds overtop very infrequently. It should be noted that salmonid migration can be cued by stormflow events, thereby concentrating the numbers of salmonids that would pass during storm events and increasing the probability of

Table 5-19 Total Number of Days per Month that Mirabel Infiltration Ponds were Overtopped from 1960 through 1995 (Computer Simulation), and Probability of Overtopping During Months in Migration Periods

Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Days per 35 Years[1]	14	9	4	0	0	0	0	0	0	0	0	5
Probability per Day	0.129	0.009	0.004	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.005
Juvenile Emigration Periods												
Coho												
Steelhead												
Chinook												
Adult Upstream Migration Periods												
Coho												
Steelhead												
Chinook												

[1] The total days the ponds could overtop is 35 years x 365 days/year = 12,775 days

entrapment. However, given the extremely low probability of overtopping during the migration period, this increase in entrapment probability is insignificant.

The risk to migrating salmonids at the Mirabel infiltration ponds also depends on the percent of river flow entering ponds during flood flows. Although the portion of surface water that enters the Mirabel ponds during flooding has not been measured, it is estimated at less than 5 percent of the flood flow. Descriptions of flooding in fish rescue reports suggest that the ponds are full within approximately 5 hours (SCWA 1998b, 1999c). During those 5 hours, a small portion of the mainstem flood flows enter the ponds. Because less than 5 percent of flood flow is ever diverted into the ponds, the risk to salmonids from flooding is low.

Another reason for the low overall risk to salmonids is that overtopping of the Mirabel ponds is rare (32 days over a modeled 35-year period). Of the three species, the risk to steelhead is lowest because the ponds overtop only during a very small portion of the steelhead juvenile migration period. Coho and Chinook salmon juveniles, more likely to be migrating through the area when the ponds overtop, are at a slightly greater risk of entrapment or migration delays. While individual fish may be affected, the overall risk to the populations is low.

This analysis is consistent with data collected during fish rescue operations (Table 5-16) (SCWA 1998b, 1999c, 2000c). Rescue efforts were not necessary in 1999 or 2000 because the Mirabel infiltration ponds did not flood. In 1998, rescue efforts at Mirabel ponds captured 12 juvenile Chinook salmon out of 3,595 fish of all species. Of these, 10 Chinook salmon were released and 2 died. One Chinook salmon mortality was probably associated with high water temperatures, and one with the rescue effort. Neither coho salmon nor naturally-spawned steelhead juveniles was captured.

Table 5-20 Number of Days by Water Year that Mirabel Infiltration Ponds Would Have Overtopped, 1960 through 1995 (Computer Simulation)

Water Year	Number of Days Exceeded[1]
WY 1960	0
WY 1961	0
WY 1962	0
WY 1963	1
WY 1964	0
WY 1965	3
WY 1966	1
WY 1967	0
WY 1968	0
WY 1969	1
WY 1970	3
WY 1971	1
WY 1972	0
WY 1973	1
WY 1974	2
WY 1975	1
WY 1976	0
WY 1977	0
WY 1978	2
WY 1979	0
WY 1980	1
WY 1981	1
WY 1982	3
WY 1983	4
WY 1984	0
WY 1985	0
WY 1986	6
WY 1987	0
WY 1988	0
WY 1989	0
WY 1990	0
WY 1991	0
WY 1992	0
WY 1993	0
WY 1994	0
WY 1995	1

[1] Number of days flows were high enough that the pond levees were predicted to overtop.

Year-to-year variation in migration periods and storm events could result in the capture of naturally-spawned steelhead or coho salmon in future years. While fry have not been captured in the ponds, it is likely that small fish would not survive for the 2-week period because cover is not available and predatory fish are present. Steelhead YOY were also generally not captured, although an unusually high number of small fish (approximately 200 individuals) were captured in Wohler Pond in 1998 after the hatchery had released approximately 150,000 surplus production juveniles (this practice has been discontinued). However, SCWA screwtrap data indicate that very few steelhead YOY are in the Wohler area prior to April (although the flood of April/May 2003 may have affected steelhead YOY that year).

Anglers report fish (species unknown) jumping in the ponds (B. Coey, CDFG, pers. comm. 2000b). Fish rescues in recent years have recovered less than a dozen adult steelhead, and most of these were at the Mirabel ponds after significant flooding in 1997 (S. White, SCWA, pers. comm. 2000). Adult steelhead were not captured in the Wohler or Mirabel ponds in 1998 or 1999. Piscivorous fish species, including Sacramento pikeminnow and bass, were also captured during fish rescues.

In 1999, structures were installed in the Mirabel ponds to reduce stress on fish, reduce residence time of fish trapped in the ponds, and facilitate rescue operations. Although fish rescues do not reduce the probability of entrapment, returning trapped fish to the river reduces mortality rates. “V” ditches and sumps installed in the ponds provide a refuge from predators and high water temperatures. They also increase the efficiency of rescue operations by concentrating fish. Although some fish may be lost to injury or stress during rescue operations, improved fish rescue operations (conducted within 2 weeks) help minimize risks to listed species. However, juvenile fish are at risk of predation during that time.

5.2.1.4 Wohler Pool

When inflated, the dam at Mirabel impounds water for approximately 3.2 miles upstream. This impoundment (Wohler Pool) decreases current velocity, which could delay emigrating smolts. Recent SCWA and NOAA Fisheries studies have documented migration delays of smolts at the dam. Data suggest that steelhead smolt outmigration is delayed when the dam is inflated (Manning et al. 2001, Manning 2003), while Chinook salmon migration is not (Chase et al. 2002).

From 2000 to 2002, radiotelemetry was used to evaluate steelhead migratory behavior, passage, and survival, using hatchery steelhead from DCFH. Results of the study are presented in Section 3. The study evaluated fish passage through the reservoir and forebay behind the dam. In 2001 and 2002, a riverine control reach was added to the study after the dam was inflated. In 2001, the dam was operated fully inflated, but in 2002, the height of the dam was decreased to increase spill depth and velocity (notch configuration) during part of the study. A key finding from the 2001 and 2002 data is that smolts traveled through the river and reservoir at approximately the same rate, despite decreased velocity in the reservoir, even over a range of river flows. Unlike travel rates, there were statistically significant differences in median residence times. River residence times did not differ between 2001 and 2002, but reservoir and forebay times dropped from 21.50 and 6.25 hours to 10.47 and 0.81 hours, respectively. There was a statistically significant difference in river and reservoir residence times in 2001, but not in 2002. Forebay time was significantly lower in 2002 than in 2001. Findings suggest that delays in emigration under baseline operations were limited to the forebay and were due to the inability of the smolts to pass the dam rather than to a decrease in current velocities within the impounded reach. This analysis evaluates a proposed operation at the dam that is designed to facilitate passage past the dam.

Notching the Dam

Under the proposed project, a depression would be created in the crest of the inflatable dam during outmigration periods (through June 15). This would provide concentrated flow at a point along the dam and a localized point of discovery for fish moving over the dam.

Observations at dams in the Columbia River system have revealed that juvenile salmonids are attracted to surface-oriented spillways (Christensen and Wielick 1995). Orifices were placed in the dam walls near the surface of the dam forebay to provide a surface collector system. When applied properly, these systems have generated more than 90 percent in fish guidance efficiencies. A 3-year study on Wells Dam documented a fish guidance efficiency of 90 percent, and fish guidance efficiencies as high as 97 percent have been recorded at other dams (Christensen and Wielick 1995).

In spring 2002, SCWA and NOAA Fisheries conducted a series of experiments that manipulated the bladder of the inflatable dam to produce an irregular crest. The team was able to create a stable notch of approximately 1.0- to 1.5-feet in the dam crest at a consistent location. Smolts subsequently moved over the dam crest through the notch. Although a small sample size (number of passing fish) did not yield statistically significant differences between notched and full-dam configurations, observations suggest that the notch is effective at reducing forebay residence time (Manning 2003).

The preliminary experiments at the dam indicate that creation of the notch in the dam crest would effectively pass outmigrating smolts by providing a detectable current and flow pathway over the dam.

The modifications to the Mirabel diversion facility include a new, flat plate-screen system and integration of the intake structure with the existing fish ladder. Integration of the intake structure and fish ladder will allow more effective use of river flows to create sweeping velocities and enhance downstream passage of fish.

5.2.2 Effects from Dam Inflation and Deflation

Inflation and deflation of the dam decrease the river stage above and below the dam, creating the potential for fish stranding upstream and downstream, respectively. The rate of change in the river stage in these areas depends on the rate the dam is raised or lowered. Rapid changes in the river stage can dewater habitat occupied by juvenile and adult salmonids. Stranding occurs when fish are separated from flowing water, and can occur in riffles, gravel bars, side channels, and backwater pools. Mortality may result if fish become desiccated or suffocate when trapped in isolated pools. Trapped fish may be at a higher risk from predation. Juvenile salmonids are more vulnerable to stranding than adults. Vulnerability to stranding drops significantly when young steelhead reach 40 mm and young Chinook reach 50 mm to 60 mm (Beck Assoc. 1989, cited in Hunter 1992).

Inflation of the dam during low-flow conditions would most likely occur in early spring when juveniles or fry of all three species may be present. The dam is generally deflated in the late fall or early winter in response to an impending storm event, and remains deflated throughout the winter. Emergency deflation may occur during the spring.

Evaluation of the effects on juvenile salmonids is based on three components: the rate of stage-change during dam inflation/deflation; habitat features in the affected area; and the frequency of dam inflation/deflation. These components are then synthesized to evaluate the overall risk. The criteria for stage-change rates are modified from the Washington Department of Fisheries guidelines (Hunter 1992). It should be noted that the Hunter (1992) guidelines are considered to represent a conservative ramping standard for the Russian River. Hunter developed his guidelines based on streams located in the Northwest, where the hydrologic regime is dominated by snowmelt processes. Those streams usually have relatively gradual changes in flow conditions. In contrast, the Russian River drainage has very "flashy" flow-runoff conditions and can experience relatively large stage changes over a short period in response to natural hydrologic conditions.

5.2.2.1 Dam Deflation

As the dam is deflated, water levels decline upstream of the dam. Flow recessions in the impounded reach (approximately 3.2 stream miles) could result in salmonid stranding or displacement. Although salmonid stranding has not been documented, SCWA staff noted stranding of warmwater fish species (suckers, tuleperch, and hardhead) in 2003 (S. Chase, SCWA, pers. com. 2003a).

Generally, the dam is lowered each fall or early winter as river flow increases. Adults, if present, are not likely to be at risk during their spawning runs because they are less susceptible to stranding than juveniles. The dam can also be lowered in early spring in response to late storms. Juvenile coho salmon, steelhead, and Chinook salmon migration periods occur during the early spring.

Rate of Stage Change

The rate of stage change in the river when the dam is lowered is estimated with a simple calculation. The dam is 11 feet high when raised and normally takes 24 hours to lower. The stage change is approximately 0.46-foot per hour (11 feet divided by 24 hours = 0.46-foot per hour). The scores for this rate of stage change are 3 for juveniles (Table 5-21) and 2 for fry (Table 5-22).

Table 5-21 Stage-Change Evaluation Scores for Dam Inflation and Deflation by Species for Juvenile and Adult Salmon

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.16 ft/hr maximum stage change.	
4	Meet 0.32 ft/hr maximum stage change.	
3	Meet 0.48 ft/hr maximum stage change.	Co, St, Ch (deflation)
2	Meet 1.4 ft/hr maximum stage change.	Co, St, Ch (inflation)
1	Greater than 1.4 ft/hr maximum stage change.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-22 Stage-Change Evaluation Scores for Dam Inflation and Deflation by Species for Fry

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.08 ft/hr maximum stage change.	
4	Meet 0.16 ft/hr maximum stage change.	
3	Meet 0.32 ft/hr maximum stage change.	
2	Meet 0.48 ft/hr maximum stage change.	Co, St, Ch (deflation)
1	Greater than 0.48 ft/hr maximum stage change.	Co, St, Ch (inflation)

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Habitat Features

Habitat features in the upstream channel also affect the potential for stranding salmonids. A low-gradient river with many side channels, potholes, low-gradient gravel bars, and an abundance of large substrates and aquatic vegetation has a greater incidence of stranding than a single-channel river with steep banks (Hunter 1992).

Habitat surveys upstream and downstream of the dam were conducted by SCWA in 1998 and 1999 (SCWA 2000b). Under free-flowing conditions, aquatic habitat upstream of the dam is dominated by run-habitat, while the downstream reach is a low-gradient channel dominated by relatively long, wide pools. When the dam is not inflated, upstream habitat consists of swiftly flowing reaches with little surface agitation and no major flow obstructions. Once the dam is inflated, upstream habitat is converted to primarily pool habitat. Typical substrate in this reach consists of sand and gravel, with fine sediments in interstitial spaces.

Bradford et al. (1995, cited in Hunter 1992) found that stranding of juvenile coho salmon was reduced when the cross-section of channel slope of the bar exceeded 6 percent. A steeper slope results in a less shallow area along the margins of the stream where fish are vulnerable to stranding. The slopes of the Russian River margins are relatively low-gradient, but are sloped to the main channel. However, the upstream habitat is primarily run or pool habitat, with relatively few structural features that would create low areas outside the main channel, such as side channels and potholes.

Because few habitat features upstream of the dam would induce stranding during the flow recessions that occur when the dam is deflated, there is little risk of stranding. Thus, the score is 4 for fry, juvenile, and adult salmonids of all three species (Table 5-23).

Table 5-23 Flow-Fluctuation Evaluation Scores Related to Opportunity for Stranding or Displacement for Fry, Juvenile, and Adult Salmon – Habitat-Related

Category Score	Evaluation Categories	Current Operations Score*
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Co, St, Ch (deflation)
3	Some habitat features that induce stranding, but area affected is small (<30%).	Co, St, Ch (inflation)
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Frequency of Deflation

The opportunity for stranding is directly related to the frequency of fluctuations in flow or stage. The dam was deflated on average approximately 1.5 times per year between 1978 and 1998, but it could be lowered as many as three times in a year (see Table 3-3, Inflatable Dam Operation History). Because dam deflation generally occurs in response to rising river flow, low-flow deflation events are rare (and limited to emergency conditions).

Flow fluctuations due to inflation/deflation occur on average only 3 times per year. Based on this analysis, the score for the effects of dam inflation/deflation on juveniles of all three species is 4 (Table 5-24).

Table 5-24 Flow-Fluctuation Evaluation Scores Related to Opportunity for Stranding or Displacement for Fry, Juvenile, and Adult Salmon – Frequency of Occurrence

Category Score	Evaluation Categories	Current Operations Score*
5	Less than 2 fluctuations per year in habitat.	
4	Between 3 and 9 fluctuations per year in habitat.	Co, St, Ch
3	Between 10 and 29 fluctuations per year in habitat.	
2	Between 30 and 100 fluctuations per year in habitat.	
1	More than 100 fluctuations per year in habitat.	
0	Daily fluctuations in habitat.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

The overall risk of frequent flow fluctuations to coho salmon, steelhead, and Chinook salmon is low. Dam deflation rates may pose a moderate risk of stranding for juvenile salmonids. The risk for fry in the spring is higher. However, there are few upstream habitat features likely to promote stranding. More importantly, springtime dam deflation, when juvenile salmonids and fry are present, occurs infrequently. When the dam is deflated in the late fall/early winter, Chinook salmon are incubating in the gravel, while small steelhead and coho salmon are primarily in tributary streams. Therefore, although some fish may be stranded, the overall risk to listed species populations is low.

5.2.2.2 Dam Inflation

Rate of Stage Change

Larger stage changes may occur when the dam is inflated than when it is deflated because river flow is likely to be lower.

When the dam is inflated, it begins to impound water and flow is reduced downstream. Water spills over the dam until it is about two-thirds inflated, then most of the flow passes through the ladders and associated bypass pipelines. Inflating the dam will change the water level downstream until stable flows through the ladders and associated bypass pipelines are established.

Under the proposed project, the two fish ladders would operate at a maximum of 20 cfs and provide a maximum juvenile bypass pipeline rate of 20 cfs. As the head behind the dam increases, flow through the ladder and bypass pipes increases until it reaches operating flows.

Water surface elevations downstream of the dam were monitored during a dam inflation event on May 22, 2003. Dam inflation began at 9:00 a.m., and monitoring began at 10:30 a.m. At 12:10 p.m., flows increased, which appeared to reduce the rate of stage-change. Calculated stage-changes ranged from 0.30 ft/hr to 0.62 ft/hr (Table 5-25). The largest stage-changes occurred near the beginning of the dam inflation. By the end of the process, stage-changes had stabilized to approximately 0.40 to 0.48 ft/hr. Stage-changes were calculated from the data as follows.

Table 5-25 Stage Changes Downstream of the Inflatable Dam during Inflation on May 22, 2003

Time	WSE (ft)	Stage Change (ft/hr)
10:30	13.30	
11:00	13.02	0.56
11:30	12.71	0.62
12:10	12.38	0.49
12:30	12.28	0.30
13:00	11.98	0.60
14:00	11.58	0.40
15:00	11.12	0.46
16:00	10.70	0.42
17:00	10.22	0.48

SCWA 2003c.

Stage-changes documented during the first half of the period of the inflation equate to a score of 2 for juveniles and 1 for fry. For this component of the evaluation, the risk to small fish downstream of the dam is high.

Habitat Features

The river downstream of the dam has long pool sections, and some shallow riffles. When the dam is inflated, a double thalweg in the run directly downstream extends for approximately 250 feet. Farther downstream, a long pool extends approximately 0.25 miles. The river constricts downstream of this pool, then becomes a shallow riffle/run before forming another long pool.

Because there are riffles downstream of the dam, the risk for stranding is slightly higher than for the upstream reach. Therefore, the score for effects of downstream habitat features on stranding during dam inflation is 3 (Table 5-23).

Overall, the risk of stranding is higher during spring inflation (and rare emergency deflation) than during dam deflation because flows are likely to be lower and fry are likely to be present. Migrating smolts are also likely to be present. Small Chinook salmon that are migrating in the early spring may be at risk, but by mid-spring, when the dam is more likely to be operational, average Chinook salmon lengths are generally longer than 60 mm FL (Chase et al. 2003), which reduces the risk. Chinook salmon averaged approximately 35 to 40 mm FL during the first few weeks of their life in 2002, then quickly grew to approximately 80 mm by mid-April. Steelhead YOY may also be at risk. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40 mm FL, but the average size increased from 44 mm to 84 mm between April and June

2000. Coho salmon fry are likely to use tributary habitat rather than mainstem habitat, and therefore have a very low risk level. Steelhead and coho salmon downstream migrants are present in the mainstem during the spring, but are much larger and therefore have a lower risk level than YOY.

Large stage changes may result in flow recessions that strand juvenile and fry on riffles downstream of the dam. However, riffles downstream of the dam tend to be short and shallow, have sand/gravel substrate, and do not provide prime habitat, which reduces the risk. Furthermore, the dam is inflated infrequently. Therefore, individual fish may be stranded, but the effect to the population would not be high.

5.2.3 Habitat Alterations in Wohler Pool

This section evaluates alterations to salmonid habitat by the impoundment of Wohler Pool related to physical habitat, temperature, DO, predation, and the potential for bank erosion.

Impoundment of water behind the inflatable dam increases upstream pool habitat. This habitat alteration could affect rearing conditions and smolt emigration for salmonids by changing the pool/run/riffle ratio, channel geomorphology, water temperatures, and species (predator) composition. In this section, data from SCWA's 5-year monitoring program are summarized and used to evaluate potential effects on salmonids. Changes in this habitat that are likely to occur under the Flow Proposal are also considered.

Under free-flowing conditions, the stream reach in the Wohler Pool area may provide rearing habitat for steelhead and Chinook salmon in the spring. This time of year, the water temperature in this part of the mainstem is optimal for salmonid growth. Chinook salmon migrate through the area by the end of June, generally before water temperatures become high (Chase et al. 2003). Coho salmon rear in the Russian River tributaries rather than the mainstem, and coho salmon YOY have not been found near the Wohler Pool (Chase et al. 2003). High summer water temperatures may limit rearing habitat in the Lower Russian River in the summer (see Section 2), even under D1610 minimum flows.

When the dam is inflated, the amount of pool habitat is increased while riffle/run habitat is decreased. This likely results in a decrease in the amount of steelhead and Chinook salmon rearing habitat. When salmonids rear in warm water, their metabolism is high and they require more food for maintenance and growth. Because transport of sufficient quantities of food (through fast water such as runs and riffles) is important for rearing, a change from run to pool habitat in the impounded reach above the dam may affect salmonid growth. Sufficient food transport is most needed during the early summer when water temperatures become warm.

Riparian vegetation could be weakened if the edges of the river become inundated, leading to bank erosion when flows increase. However, the width of the upstream wetted channel is not significantly different when water is impounded by the dam compared to the rainy season when the river flows freely. Therefore, the proposed project is not likely to lead to increased bank erosion.

5.2.3.1 Steelhead Rearing in Wohler Pool

Steelhead YOY were captured downstream of the dam in the spring of all years sampled with the rotary screw trap (Chase et al. 2002, 2003) (see Table 2-10). A few steelhead YOY were also captured in the Wohler Pool during electrofishing surveys in August 2000 through 2003. These fish were generally larger than similar-age steelhead captured in Mark West and Santa Rosa creeks during fall surveys (Chase et al. 2003), suggesting that growth rate in the river may be higher. Eight wild and one hatchery steelhead were captured during the August 2001 sampling event. The captured wild steelhead ranged in length from 105 mm to 225 mm, and consisted of all year classes (Ages 0+ to 4+). The large number of steelhead YOY documented in the 2002 rotary screw trap data suggest that some steelhead may be rearing in this portion of the mainstem under baseline conditions.

The impoundment converts steelhead habitat in the mainstem to pools, which may negatively affect summer growth. However, juvenile steelhead are not likely to be abundant in Wohler Pool in the summer. Not only are summer water temperatures too high to provide suitable summer rearing habitat in this portion of the mainstem, but a relatively small portion of the river is affected. Therefore, the risk to the population is low.

5.2.3.2 SCWA Wohler Pool Habitat Data Collection

SCWA has collected habitat data in four reaches of the Wohler Pool area since 1999, as part of a 5-year study (Chase et al. 2000, 2001, 2002, 2003).

- Reach 1, located downstream (approximately 2.5 km [1.5 miles]) of the inflatable dam adjacent to Steelhead Beach Regional Park.
- Reach 2, located in lower Wohler Pool.
- Reach 3, located in upper Wohler Pool.
- Reach 4, located upstream of Wohler Pool in a relatively shallow glide (maximum depth 1.5 to 2.0 feet). Minimally affected by dam operations.

Average widths and depths were similar between the four reaches, except for a small hole (5.0-m deep) at the upstream end of Reach 3. Overall percentages of cover (e.g., overhanging vegetation and woody debris) were similar in the three reaches upstream of the dam.

All four reaches provide suitable habitat for piscivorous fish species (i.e., bass and Sacramento pikeminnow). The lower half of Wohler Pool provides the best habitat for smallmouth and largemouth bass because it has the deepest water, the lowest current velocities, and the most abundant cover. During the winter/early spring, when streamflows are decreasing (prior to dam inflation), low-velocity, deep-water habitat is still available in Reaches 1, 3, and 4. Reach 1 is a main-channel pool under summer base flows, and as high winter flow subsides, habitat returns to this condition. Therefore, low-flow velocity refuge remains throughout the winter-to-summer transition period. Reach 4 is also primarily pool habitat.

Without the dam, Reach 3 would be classified primarily as a run/glide habitat. The thalweg runs against one of the banks, so that as streamflow decreases from winter to summer flows, moderate depths and cover (mainly overhanging vegetation and large woody debris) provide velocity refuge for fish. Habitat in the lower half of Reach 2 consists of a series of relatively shallow riffles and glides with moderately high-velocity currents, and the thalweg runs through the middle of the channel, away from overhanging vegetation. Refuge from the relatively high-velocity currents is lacking during the winter-to-summer transition period in the lower portion of Wohler Pool.

5.2.3.3 Temperature in Wohler Pool

During SCWA's 5-year study at Wohler and Mirabel facilities, water quality (water temperature, DO, and conductivity) has been monitored under D1610 flows at stations located approximately 6.5 km upstream to 2.3 km downstream of the dam (Chase et al. 2000, 2001, 2002, 2003). These data are used to characterize project effects.

When the dam is inflated, it increases the residence time and surface area of water in the pool, resulting in greater solar heating. Higher temperatures could potentially affect salmonid rearing and migration. Since 1999, a series of water-temperature monitoring stations upstream, within, and downstream of Wohler Pool has been used to record water temperatures. Water temperature and DO profiles have also been collected periodically at the reach stations.

The water temperature monitoring study objectives are threefold and are listed in order of highest to lowest priority:

1. Evaluate whether water impoundment behind the dam increases the rate of warming relative to free-flowing conditions.

2. Provide a general description of the spring-through-fall thermal regime within the study area and compare it to the temperature requirements of salmonids and predatory fish species.

3. Assess the potential for thermal stratification in Wohler Pool.

The Flow Proposal would alter summer flows in this portion of the mainstem. Therefore, the thermal regime is likely to change. However, the data collected under D1610 flows can be used to generally characterize the effects that impoundment may have on salmonid species.

Wohler Pool is shallow (approximately 2 m to 3 m) and did not show thermal stratification (Chase et al. 2000, 2001, 2002, 2003). Therefore, cold-water refugia have not been created in the impoundment during the 1999 through 2002 sampling seasons.

The SCWA study compared water temperature data with standards proposed by the NCRWQCB (2000) to generally characterize habitat in this portion of the lower river. These standards recommend that the maximum weekly average water temperature for rearing juvenile steelhead should not exceed 17.8ºC and the maximum weekly water temperature should not exceed 23.9ºC. Site-specific temperature tolerance data are not available for salmonids in the Russian River basin, and these criteria may be conservative.

In 2000, during the peak smolt emigration period (mid-April through mid-May), weekly average water temperatures ranged from 16.1°C to 17.4°C, which are suitable for smolt emigration. Water temperatures increased rapidly to over 20.0°C in May and ranged from 20.9°C to 23.6°C in June. Compared to the proposed water temperature standards for the Russian River, these temperatures were suboptimal for a portion of the smolt emigration period and steelhead rearing period. However, suboptimal temperatures were documented upstream of the influence of the impoundment as well as within the impoundment, which indicates natural warming in this portion of the mainstem and results in high summer water temperatures.

In spite of the high temperatures, juvenile steelhead were captured in Wohler Pool during an August 2000 electrofishing survey and were observed by video monitoring in the fish ladders throughout the summer. Healthy-appearing Chinook salmon and steelhead smolts were captured in Wohler Pool in 2001, even when maximum daily surface temperatures were as high as 25.2°C. Steelhead juveniles were also documented in the Wohler Pool throughout the summer months.

Temperature Increases

Data from SCWA monitoring indicate the impoundment has only a small effect on the rate at which water warms (Chase et al. 2002). Data collected in 2001 are used to characterize the effects of the dam on water temperature and represent the thermal regime of Wohler Pool. Data from 2003 are similar to 2001 data, except there was a smaller increase in temperature in Wohler Pool (Chase et al. 2003).

To evaluate the amount of warming in Wohler Pool relative to natural heating and cooling trends, seven water temperature monitors were deployed in 2001, as follows:

- Station 1, located 11.5-km upstream of the dam, which is 6.4-km upstream of the influence of the dam.
- Station 2, located 5.1-km upstream of the dam, and at the upstream end of the Wohler Pool impoundment.
- Stations 3 and 4, located in the upper two-thirds and middle of Wohler Pool, respectively.
- Station 5, located at the dam.

- Station 6, located immediately below the dam.

- Station 7, located approximately 2.3-km downstream of the dam.

Stations 1 and 2 provided data about the natural heating/cooling of the mainstem upstream of Wohler Pool. Stations 3, 4, and 5 characterized thermal conditions within the impoundment. The 5.1-km reach between Stations 2 and 5 covers the region where thermal warming and cooling takes place in the impoundment.

The rate of increase in the average monthly surface temperature between Stations 1 and 2 ranged from 0.06°C to 0.10°C/km between June through September 2001. This resulted in an overall change of 0.4°C to 0.7°C per month over the 6.5-km distance during this time. Between Stations 2 and 5 (Wohler Pool) the rate of increase ranged from 0.04°C to 0.16°C/km during the same time-period. This resulted in an overall change of 0.2°C to 0.9°C over the 5.1-km distance in a month. Rates and magnitudes of change were smaller in bottom waters. Between Stations 6 and 7 (downstream of the dam), the rate of increase ranged from 0.10°C/km to 0.30°C/km, resulting in an overall monthly change of 0.4°C to 0.5°C over the 2.3-km distance.

Using the rate at which water temperatures increased in the unimpounded reach upstream of Wohler Pool (between Stations 1 and 2) as a baseline, the difference between the rates of increase in the Wohler Pool reach (between Stations 2 and 5) with and without the impoundment were estimated. This difference is the estimated increase in temperature above natural warming created by the Wohler Pool impoundment (Table 5-26). The analysis shows that during the warmest months (June through September), Wohler Pool could increase the average monthly water temperatures 0.1°C to 0.6°C above natural warming in surface waters, and from 0.3°C to 0.6°C in bottom waters. For example, average monthly water temperature would be increased by an additional 0.6°C in June of 2001, raising it from 20.6°C to 21.2°C. Applying water temperature scores for steelhead, there would be no change in score in surface waters and a decrease in bottom temperature scores from 3 to 2 in July and August.

Table 5-26 Estimated Increases in Water Temperatures above Natural Warming in the Wohler Pool (June to September 2001), and Change in Steelhead Temperature Score

Month	Estimated Increase Above Natural Warming (°C)	Estimated Effect on Average Monthly Water Temperature (°C)	Change in Steelhead Temperature Score
	Surface (0.5 m)		
June	0.6	20.6 to 21.2	2 (no change)
July	0.5	20.5 to 21.0	2 (no change)
August	0.3	20.3 to 20.6	2 (no change)
September	0.1	18.6 to 18.7	2 (no change)

Table 5-26 Estimated Increases in Water Temperatures above Natural Warming in the Wohler Pool (June to September 2001), and Change in Steelhead Temperature Score (Continued)

Month	Estimated Increase Above Natural Warming (°C)	Estimated Effect on Average Monthly Water Temperature (°C)	Change in Steelhead Temperature Score
	Bottom (3.0 m)		
June	0.4	20.5 to 20.9	2 (no change)
July	0.6	19.9 to 20.5	3 to 2
August	0.6	19.7 to 20.3	3 to 2
September	0.3	18.2 to 18.5	3 (no change)

Changes in Temperature under Flow Proposal

These data estimate the increase in warming for flows under baseline operations. Under the Flow Proposal, water temperature would increase, particularly downstream of the dam where summer flow would be reduced. Nevertheless, these data indicate the Wohler Pool impoundment results in only small increases in summer water temperature (0.1°C to 0.6°C per month over the length of the impoundment) above natural warming.

Under the Flow Proposal, summer flow in the Lower Russian River downstream of Dry Creek would be lower than under D1610 under current conditions, and summer water temperatures would be warmer (Table 5-27). Modeled flow and water temperatures are discussed in greater detail in Section 5.3. Predicted median water temperatures would be about half a degree warmer below Dry Creek under the Flow Proposal during the warmest summer months. At Hacienda Bridge, median water temperatures are predicted to be similar in June, but would increase in July through September. These model results suggest that summer water temperatures in Wohler Pool may be approximately half a degree higher as well, and water temperature downstream may be as much as 0.6ºC higher.

Table 5-27 Predicted Median Flow and Water Temperature in the Lower Russian River under Current Demand

	June	July	August	September
Below Dry Creek				
		Flow (cfs)		
D1610	320	292	282	246
Flow Proposal	236	174	179	179
		Temperature (ºC)		
D1610	21.2	22.6	22.2	20.5
Flow Proposal	21.6	22.9	22.7	20.9

Table 5-27 Predicted Median Flow and Water Temperature in the Lower Russian River under Current Demand (Continued)

	June	July	August	September
Hacienda Bridge				
		Flow (cfs)		
D1610	279	197	174	148
Flow Proposal	188	78	68	78
		Temperature (ºC)		
D1610	21.4	23.5	23.4	21.6
Flow Proposal	21.4	24.0	24.1	22.2

Based on modeled flow and water temperatures from the RRSM.

Effects of Temperature Changes on Salmonids

As discussed earlier in Section 5.2.3, a few steelhead may potentially rear in the area all year, but coho salmon have not been observed rearing through the summer near the Wohler Pool. Chinook salmon have not generally been observed rearing through the summer, although two Chinook salmon were captured in 2002, marking the first time this species was captured during electrofishing surveys. As salmonid smolts have generally migrated out by the end of June, increases in water temperatures are not likely to substantially affect smolt migration.

Temperature monitoring indicated that temperature in the late spring is optimal for growth of young salmonids in the Mirabel and Wohler areas. Steelhead YOY sizes doubled, and sometimes tripled, during the spring. Data indicate that summer water temperatures may be too high to support adequate growth, and juvenile steelhead leave the area by mid-July. However, healthy-appearing Chinook salmon and steelhead downstream migrants were captured during periods when maximum daily surface temperatures ranged up to 23.2ºC, and juvenile steelhead were captured and observed in the Wohler Pool throughout the summer months in 2002. During periods of elevated water temperatures (up to a temperature range where physiological stress occurs), juvenile salmonids may be healthy as long as sufficient food is available to support a higher metabolism (see Appendix C for a discussion of water temperature criteria). It is not known if steelhead YOY found in these areas during the spring or summer migrate to areas where water temperatures are cooler. It is possible that these steelhead YOY suffer mortalities as the quality of rearing habitat degrades with naturally high summer temperatures.

Temperature increases above natural warming in the Wohler Pool impoundment (upstream of the dam) are small under D1610 flow conditions. Under the Flow Proposal, summer water temperatures may be approximately half a degree higher than under D1610 (see Section 5.3 for an analysis of temperature in the Lower Russian River under the Flow Proposal). This could result in a change in the quality of rearing habitat for steelhead in the warmest summer months. However, summer water temperatures upstream of the impounded area are naturally high, and it is likely that poor rearing conditions may occur in this part of the mainstem during the hottest part of the summer, whether Wohler Pool is there or not.

5.2.3.4 Dissolved Oxygen in Wohler Pool

DO data from water quality profile monitoring in 1999 indicate the monitoring site at the dam had DO levels that ranged from a low of 6.7 mg/l to a high of 9.0 mg/l. DO levels at the upstream control site were slightly higher. Applying DO criteria for rearing, scores for all three species are 4 for levels greater than 6.5 mg/l and 5 for levels greater than 8.0 mg/l. Adequate DO levels were also found in subsequent years. Since scores of 4 or 5 were achieved during this monitoring period, it appears that DO levels have not been negatively affected by operations at the dam.

5.2.3.5 Predation in Wohler Pool and at the Inflatable Dam

Wohler Pool could increase habitat favorable for predatory fish species, which may increase the number of predators in this reach. Furthermore, juvenile fish migrating downstream past the dam could be concentrated in the notch of the dam or in the fish ladders as they pass, which would make them vulnerable to predation.

Predators sampled during electrofishing surveys from August 1999 to 2002 include Sacramento pikeminnow and non-native smallmouth and largemouth bass (Chase et al. 2003). Pikeminnow are native to the Russian River and are widespread upstream of Wohler Pool. They were observed in most large pools sampled during a 2002 snorkel survey (Cook 2003a). Striped bass (non-native) are known to occur in the Lower Russian River, but only two individuals have been captured in the study area during 4 years of sampling. Wild and hatchery salmonids have been collected in relatively low numbers, primarily in Wohler Pool.

Two of the most important factors that affect the risk of predation for salmonids are abundance and size of the predators. Small predators would find it difficult to prey on salmonid smolts. Zimmerman (1999) found that the maximum length of salmonids consumed by adult smallmouth bass and northern pikeminnow was linearly related to predator length (the northern pikeminnow and Sacramento pikeminnow are closely related), and that smallmouth bass consumed smaller juvenile salmonids than pikeminnow. The mean maximum length of salmonids consumed in the Zimmerman (1999) study was 119 mm FL (40 percent of predator length) for smallmouth bass and 167 mm FL (43 percent of predator length) for northern pikeminnow. Based on his regression, a 200-mm FL smallmouth bass can consume a 100-mm FL salmonid, and a 400-mm FL smallmouth bass can consume a 138-mm FL salmonid. Similarly, a pikeminnow between 250 mm to 530 mm FL can consume salmonids ranging from 116 mm to 220 mm FL. Based on a literature review conducted for the Mirabel sampling program, fish are generally not part of the diet for pikeminnow that are less than 200 mm. For pikeminnow 200 to 300 mm FL, fish are a small portion of the diet, and for those greater than 300 mm FL, fish are a significant part of their diet (Chase et al. 2003). The largest predators captured to date have been a 430-mm FL smallmouth bass (captured in 2003), a 726-mm FL pikeminnow (2003), and a 460-mm FL largemouth bass (2002).

Moyle (2002) reports that Sacramento pikeminnow greater than 200 mm standard length (SL) feed primarily on fish. Under natural conditions, Sacramento pikeminnow feed largely on nonsalmonid fishes. However, they may have a significant impact on salmonids where anthropogenic factors create situations that reduce the ability of juvenile salmonids to avoid predation, such as below dams, and they can travel large distances to feed (Moyle 2002).

The 1999 reconnaissance sampling program data provided an indication of the size of salmonids. Scale sample analysis indicates that steelhead primarily emigrate at Age 2+. In addition to steelhead and Chinook smolts, some steelhead YOY were captured in 1999 and 2000. Data indicate that some steelhead smaller than 60 mm (NOAA Fisheries definition of fry-sized) were present in early April, but that average sizes of steelhead were larger than 60 mm by the end of May, and greater than 80 mm by the end of June (Chase et al. 2000).

Chinook salmon emigrate through the Wohler Pool at an average of 90 mm FL (range approximately 35 mm to 140 mm), and steelhead at 175 mm (range 145 mm to 250 mm) (Chase et al. 2002). Chinook salmon averaged approximately 35- to 40 mm FL during the first few weeks of their life in 2002, then quickly grew to approximately 80 mm by mid-April. Chinook salmon emigrating in the spring would potentially be most vulnerable. Steelhead YOY rearing in the impounded area in the spring may also be at a greater risk. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40-mm FL. The average size of steelhead YOY increased from 44 mm to 84 mm between April and June 2000.

The data suggest that pikeminnow attain a size sufficient to prey on Chinook salmon smolts at the beginning of their third year of life (Age 2+). Pikeminnow Age 4+ or older are large enough to prey on both Chinook salmon and steelhead (Chase et al. 2001).

Boat electrofishing, conducted in August 1999 to 2002, sampled the fish community in the four reaches near the inflatable dam (see Section 5.2.3.2 for reach locations). The abundance of pikeminnow greater than 200-mm FL in the study area appears to be relatively low (Table 5-28). In 1999, 3 of 13 pikeminnow captures were large enough to prey on salmonid smolts. In spring 2000, a spot electrofishing survey captured two large pikeminnow. Because no tagged pikeminnow were recaptured during the second phase of the sampling program, it was not possible to estimate the population of pikeminnow longer than 200 mm FL. Several large pikeminnow were captured in 2001 and 2002. Although few adult pikeminnow were captured over the 4 years sampled, they are a long-lived species (up to 16 years [Moyle 2002]), and were large enough to feed on Chinook salmon and steelhead smolts.

In the same 1999 study, smallmouth bass averaged 85 mm FL in August of their first year and 179 mm in August of their second year. Growth rate of these fish determined by back-calculating length, gives an estimate as to what age smallmouth would become large enough to feed on Chinook salmon smolts. Smallmouth bass likely attain a size sufficient to prey on Chinook salmon at Age 2+.

Table 5-28 Size and Age of Sacramento Pikeminnow Captured in August Surveys (1999 to 2002) in Russian River Reaches 1 through 4

Age Class[1]	Average Length (mm FL)	Length Range (mm FL)	N[2]
Sacramento Pikeminnow (Average over the 1999 to 2002 August Sampling Season)[3]			
0+	66	35–95	161
1+	139	110-175	75
2+	252	195-300	15
3+	353	320-385	11
4+	459	410-455	6
Age 5+	531	515-555	8
Age 6+ or older	660	590-710	10

[1] Ages based on length-frequency histogram and scale analysis (Chase et al. 2003).

[2] Normally, younger age classes would be expected to have larger numbers of fish than older age classes within a population.

[3] In the 2002 sampling season, in addition to the pikeminnow caught during the regular electrofishing sampling event, 15 additional pikeminnow greater than 200 mm FL were captured during a “predator” sampling event (20 total for the season).

Smallmouth bass were the most abundant species inhabiting the study area. Although many YOY fish were captured, no smallmouth bass large enough to prey on steelhead smolts and very few large enough to feed on Chinook smolts were captured in the years surveyed (Table 5-29). The low number of older smallmouth bass could be due to high bass YOY mortality, or to a high rate of emigration out of the study area. When the dam is deflated in the winter, recruitment of the smallmouth bass to older age classes may be low because a return to free-flowing conditions in the Russian River may limit juvenile survival.

Very few largemouth bass were captured, and abundance was highest in Reach 1 in all years sampled. Age 2+ fish may be large enough to feed on at least the smaller-sized emigrating Chinook salmon smolts.

Table 5-29 Smallmouth and Largemouth Bass Large Enough to Prey on Salmonids that were Captured in August Surveys (1999 to 2002) in Russian River Reaches 1 through 4

Age Class[1]	Average Length (mm FL)	Length Range (mm FL)	N/year
Smallmouth Bass			
2+	267	220-310	11-46
3+	336	300-380	2-6
4+	389	375-405	1-3
Largemouth Bass			
2+	192	175-220	0-5
3+	254	250-255	0-2
4+ or older	388	310-460	0-3

[1] Ages based on length-frequency histogram and scale analysis (Chase et al. 2003).

SCWA electrofishing data from 1999 to 2002 showed that very few adult pikeminnow and smallmouth bass were present, despite an increase in pool habitat. Catch per unit effort (CPUE) is an indicator of a species' relative abundance and can be used to compare data between sampling sites of unequal sampling effort (e.g., length, time sampled). A comparison between reaches shows that CPUEs for large (Age 2+ or greater) Sacramento pikeminnow and smallmouth bass were similar between reaches in 2001 (Chase et al. 2003).

Evaluation of Predation Risk

The risk of predation is evaluated in three components: 1) the extent to which a project operation or structure concentrates prey in an area where predators are present; 2) potential changes in predator access to salmonid populations; and 3) project effects on water temperature, which may affect the risk of predation on juvenile salmonids. These criteria are applied to Wohler Pool and the dam. Finally, the components are synthesized for an overall risk assessment.

For the first component, the data suggest that while juvenile predators, particularly smallmouth bass, may be relatively abundant, predators that are large enough to prey on steelhead or salmon smolts are not. There are no features within Wohler Pool that concentrate salmonids. Therefore, the score for Wohler Pool is 4. Because migrating salmonids are concentrated at the inflatable dam when they pass (notch and fish ladders), the score is 3 (Table 5-30). Although the dam may briefly concentrate migrating fish in the notched configuration, the 2002 and 2003 findings suggest that the notch significantly reduces forebay residence time and that fish do not concentrate near the notch or in the forebay.

Table 5-30 Predation Evaluation Scores for the Inflatable Dam – Structural Component

Category Score	Evaluation Criteria	Current Operations Score*
5	No features that concentrate salmonids or provide cover for predators, concentrations of predators not found.	
4	No features that concentrate salmonids, predator cover near, predators in low abundance locally.	Wohler Pool (Co, St, Ch)
3	Features that concentrate salmonids, no predator cover nearby, predators in medium to low abundance locally.	Inflatable Dam (Co, St, Ch)
2	Features that concentrate salmonids, predator cover nearby, predators in medium to low abundance locally.	
1	Features that concentrate salmonids, predators abundant locally.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Only small numbers of smallmouth bass are found in the Wohler Pool despite the large numbers of juveniles. It is possible that the seasonal nature of the impoundment limits success of the juvenile bass population. Perhaps juvenile bass reproduction can be successful when the dam is inflated, but a return to free-flowing riverine conditions in the wet season makes it difficult for the young fish to survive.

The second component assesses predator access. Because the operation of the inflatable dam does not affect access for predators, this component of the evaluation criteria does not apply. Predators are able to pass through normal river flows when the dam is deflated, and may still pass through the fish ladder when the dam is inflated. Native and introduced warmwater predators were already established in the mainstem Russian River prior to use of the inflatable dam. Therefore, passage of predators through the fish ladder is not likely to introduce a new risk.

The third component assesses habitat conditions and, in particular, the suitability of temperatures for warmwater predators. SCWA monitored the temperatures in the impounded area of the dam (Wohler Pool) and reaches above and below, and estimated the increase in water temperature above natural warming that occurs in Wohler Pool (Chase et al. 2003). The average monthly water temperatures of surface waters in the impoundment would result in a score of 2 and in bottom waters, scores of 2 and 3 (Table 5-26). The estimated average monthly increase above natural warming ranged from 0.1 to 0.6°C, which suggests natural warming is a much more significant contributor to high summer water temperatures than project operations.

While the inflatable dam does not appear to significantly increase water temperatures favorable to warmwater predators, it increases the amount of predator habitat by significantly increasing the percentage of pool habitat above the dam for part of the year. Wohler Pool may function as a nursery for younger age classes of smallmouth bass and pikeminnow. Once deflation occurs, these younger age classes could disperse to other areas of the river and help sustain local populations. However, other nursery areas exist in the lower Russian River or in tributary habitat as well, and populations were established prior to operation of the dam. Because Wohler Pool may form relatively favorable summer/fall habitat compared to free-flowing, upstream or downstream mainstem reaches, data on species composition within the pool provide a conservative surrogate to estimate the overall risk of predation to juvenile salmonids. SCWA electrofishing data from 1999 to 2002 showed that very few adult pikeminnow and smallmouth bass were present, despite an increase in pool habitat. Wohler Pool does not provide additional year-round juvenile or adult habitat. The best available information suggests that Wohler Pool provides additional early rearing habitat that may help sustain local populations of predatory fish, but the data do not indicate the presence of Wohler Pool increases the overall carrying capacity of this portion of the mainstem.

In summary, pool habitat that would favor warmwater predator communities is created above the inflatable dam, but predators large enough to prey on juvenile salmonids have been found in only limited numbers. Although few pikeminnow were captured during all years sampled, they can attain a size large enough to feed on both Chinook salmon and steelhead smolts. Smallmouth bass were the most abundant species sampled in the study area. No smallmouth bass large enough to prey on steelhead smolts and very few smallmouth bass large enough to feed on Chinook smolts were captured. Data from sampling indicate that most of the predators sampled in this habitat were not large enough to be a significant threat to juvenile salmonids.

Yet even without the inflatable dam, warmwater species that prey on salmonids would be present. The operation of the dam does not introduce new predators to an area where they have not traditionally been. Water temperatures are suitable for warmwater predators, but operation of the dam increases water temperatures only slightly above natural warming. Salmonids are not concentrated in Wohler Pool. The inflatable dam may briefly concentrate migrating fish in the notched configuration, but 2002 and 2003 study results suggest that the notch significantly reduces forebay residence time and that fish do not concentrate near the notch or in the forebay. Overall, the inflatable dam may slightly increase the risk of predation on listed salmonid juveniles by increasing the amount of predator habitat and concentrating fish in the notch or fish ladder when they pass. But risk due to project operations is likely to be low.

5.2.4 Maintenance Activities

5.2.4.1 Inflatable Dam

Before the dam is raised, it may be necessary to remove gravel that has accumulated during the winter on top of the dam and in the fish ladders, although it has not been necessary in recent years. This activity could increase sediment input to the river or potentially entrain juvenile salmonids. This practice would most likely occur in the spring when juvenile salmonids of all three species are present.

A portable suction dredge removes accumulated gravel and the dredge discharge is routed to a temporary siltation (settling) pond to prevent turbid water from reaching the river. The water is allowed to re-enter the river after the sediment has settled, and spoils are removed or stored out of the flood plain. This practice is sufficient to reduce the risk of increasing suspended sediment concentrations in this vicinity of the river. Because suspended sediments are allowed to settle in a settling pond, the score for sediment containment is 3 (Table 5-31). Spoils are not placed where they would result in disturbance to the streambed or streambanks, so the score for upslope sediment control is 5. This maintenance activity would not likely put juvenile salmonids at risk.

In the area that the portable suction dredge is used, there is ample opportunity for young fish to escape the disturbance in the area. Therefore, the risk to juvenile salmonids in those years that the dredge is needed is likely to be low. However, because small salmonids may be present, there is the chance that occasionally one or more fish may be entrained by the suction dredge. The relatively small area that is maintained, combined with the fact that this maintenance activity is not needed every year, suggests that the number of fish subject to this risk is likely to be small.

Table 5-31 Sediment Containment Evaluation Scores for Inflatable Dam Maintenance

Category Score	Evaluation Category	Current Operations Score*
	Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No sediment control.	
	Upslope Sediment Control (Spoils Storage)	
5	No upslope disturbance, or increase in upslope stability.	Co, St, Ch
4	Limited disturbance with effective erosion control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

5.2.4.2 Vegetation Removal

Vegetation is controlled along access roads to levees associated with water supply operations. Vegetation is removed with an herbicide that is applied by hand and approved for aquatic use. Levee roads are mowed in the late spring each year. Juvenile emigration for all three species occurs during this time.

Vegetation removal does not occur on the streambank, but rather on roads upslope of the river. The main levee road on the west side of the river in the Mirabel area is approximately 250 feet from the river. It provides access to the Mirabel collector wells, infiltration basins, diversion caisson, and the west side of the inflatable dam. It also is used as an access location for periodic scraping of gravel bars that form under and upstream of the Wohler Bridge. The access road at Wohler is a dirt road used to access the Wohler collectors, and it continues south along the east side of the river to access the east side of the inflatable dam. This road is approximately 200 feet from the river. Both roads end at the river near the inflatable dam, but herbicides are not used on the road adjacent to the river. Because the roads are 200 or more feet from the river, this maintenance is not likely to affect the riparian vegetation adjacent to the river. Effects of vegetation control are scored to evaluate the use of an herbicide (Table 5-32). A score of 4 indicates that significant short-term effects from the use of this herbicide are not likely to occur. Because the active component of this herbicide is short-lived, application in upslope areas away from the stream may not result in any contact with the stream.

Table 5-32 Vegetation Control Scores for Levee Roads

Category Score	Evaluation Category for Herbicide Use	Current Operations Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use.	Co, Ch, St
3	Moderate to heavy use of herbicide approved for aquatic use.	
2	Use of herbicide not consistent with instructions.	
1	Herbicide not approved for aquatic use.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Improper use of this herbicide could result in contamination of the water and harmful effects on listed species. However, SCWA has a training program for maintenance workers and with prescribed use, the risk is minimal.

5.2.5 Water Treatment and Facility Maintenance Substances

Substances used to treat water include chlorine, an orthopolyphosphate compound, and caustic soda (sodium hydroxide). Each substance is contained in accordance with strict regulations, and would not be released under normal conditions. Any significant risk to listed species would be due to accidental spills. For the substances discussed below, the risk of an accidental spill and subsequent exposure to fish in the river is minimized by in-place and up-to-date Spill Prevention, Containment, and Control (SPCC) plans.

5.2.5.1 Chlorine

Chlorine is normally delivered to SCWA's chlorine buildings in pressurized cylinders that are constructed in accordance with strict regulations and that are capable of withstanding severe shock if they are dropped. SCWA buildings that house chlorine are equipped with leak-detection alarm systems and are located at a considerable distance from the river (approximately 250 yards). These measures are likely to reduce the likelihood of accidental releases of concentrated chlorine to the river. Furthermore, calcium hypochlorite is currently used at the Sebastopol Road and Todd Road well sites, eliminating the need for chlorine gas cylinders at the sites. This system will be installed at the Occidental Road well in the future.

Minor amounts of chlorinated water are discharged from the Ranney collector wells and other nearby facilities. Water from motor cooling lines is discharged at an estimated rate of approximately 5 gpm when the pump motors are running. This discharge water flows into the settling and infiltration ponds at the Mirabel facilities, and into the Russian River at Wohler. These incidental discharges and the pipeline discharges are covered under a waiver issued by the NCRWQCB. SCWA is looking into other options for cooling to alleviate this discharge.

Maintenance of the water storage tanks requires that the tanks be emptied periodically. A portion of the water is released to surface water drainage. SCWA maintenance staff adds a dechlorinating chemical to eliminate any chlorine residue in the discharge. If water levels in the tank unexpectedly rise too high, overflows may occur. In this case, water with a chlorine level of approximately 0.6 ppm may be discharged to surface water drainage.

In general, normal operation and maintenance activities are performed with trained personnel and under stipulations and regulations provided by permits. Because chlorine would be in the form of a gas, if spilled, the likelihood of it entering the water in severe concentrations is limited. A catastrophic spill in the water from storage tanks could have severe consequences but would be limited in area. The SCWA SPCC plan minimizes this to nearly no risk. Normal operations do not appear to present a significant risk to the threatened fish species of the area.

Accidental spills from the water transmission system have the potential to introduce chlorinated water to streams in the watershed. SCWA has added dechlorination baskets and alerts to each of 17 valves that could result in a spill of potable water if they fail. Because chlorine would be removed from the water, there would be no negative effects to salmonids. An alert would notify SCWA if there is a problem so that it could be corrected.

5.2.5.2 Caustic Soda

Caustic soda is delivered by tanker trucks as a solution of 50 percent water and 50 percent caustic soda. Storage facilities are designed to keep the substance contained. The Wohler pH control building is located approximately 250 yards from the river, and the River Road pH control building is approximately 200 yards from Mark West Creek. The concrete masonry walls of the pH control buildings are designed to provide secondary containment in the event a leak occurs. Although a catastrophic spill that entered the river would be serious, the SPCC measures should be adequate to minimize the risk of an accidental spill to nearly nothing, and distance from the river further minimizes the risk to salmonids.

5.2.5.3 Orthopolyphosphate

A pilot treatment system is in place at the Todd Road well that adds a small dose of an orthopolyphosphate compound to the well water. This treatment is used to eliminate the hydrogen sulfide odor that occurs at all three wells. The SPCC plan provides maximum protection from an accidental spill and the risk is little to none.

5.2.5.4 Hydrocarbons

The only significant potential effect related to hydrocarbons is diesel fuel storage. A catastrophic spill into the Russian River would have serious effects. Because of the adherence to local and federal regulations and guidelines (i.e., SPCC plans), it appears highly unlikely that a major spill would occur. Approximately 31,000 gallons of diesel fuel are stored adjacent to the standby generators at Wohler and Mirabel for use in powering standby generators. Both diesel storage locations are approximately 250 yards to 300 yards from the Russian River and are in above-ground, double-containment tanks, which would indicate that if a spill did occur it would be unlikely to enter the Russian

River. Concrete block walls around fuel tanks provide additional containment capability. Fuel tanks are designed, manufactured, and constructed in accordance with the Uniform Fire Code, the Uniform Building Code, and applicable local codes and ordinances. Spill prevention and response is outlined in the SCWA SPCC plan, which is kept updated per state and federal regulations.

5.2.6 WATER SUPPLY AND TRANSMISSION SYSTEM PROJECT

SCWA is in the process of environmental review of the program-level impacts of the WSTSP. The facilities proposed under the WSTSP are included in this BA as an approximate future model against which effects to salmonids from future water supply development may be analyzed. The actual water supply facilities and diversions from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated in the WSTSP.

The WSTSP would implement water conservation measures to save approximately 6,600 AFY; increase the amount of water diverted from the Russian River (rediversion of stored water and direct diversion of winter flow) from 75,000 AFY to approximately 101,000 AFY; and increase the transmission system capacity from 92 mgd to 149 mgd.

Diversion facilities would include Ranney-type collector wells, conventional wells, infiltration ponds, surface-water diversion structures, water treatment facilities, pumps, connecting pipelines, and appurtenances. As with the existing facilities, potential effects of these facilities include changes to instream flow, passage past project facilities for adult and juvenile salmonid migration, water quality-related effects and alteration of habitat from construction, and operation and maintenance activities.

Distribution facilities would include pipelines and booster pump stations, as well as an additional 55.5 million gallons of storage (steel storage tanks). As with existing facilities, potential effects may be related to use of water treatment and facility maintenance substances.

5.2.6.1 Additional Diversion Facilities

Additional diversion facilities would have the potential to alter groundwater or instream flow. However, under the Flow Proposal, instream flow would be managed to improve flow-related habitat for fish. Effects of the proposed water management are discussed in Section 5.3.

The additional diversion facilities have the potential to affect adult and juvenile salmonid migration past the facilities. Under the proposed project, all diversion facilities would be equipped with fish screens that meet NOAA Fisheries and CDFG fish-screen criteria for fry and juvenile salmonids. Therefore, fish would pass without injury or delay. Furthermore, any additional infiltration ponds would likely be located away from the stream, or graded and designed to minimize the risk of entrapment during high-flow storm events.

Construction of additional facilities such as collector wells and infiltration ponds would occur away from the stream and would have no effect on salmonids or their habitat. Construction of surface water diversions could occur and if constructed would include measures that minimize effects to salmonids and their habitat. Sediment control during construction would be implemented as appropriate for a particular site. Therefore, construction activities would unlikely to result in harmful sediment input to the waterway.

Construction of additional facilities is likely to result in removal of vegetation, and riparian vegetation may be affected. Under the proposed project, native vegetation would be planted to mitigate for the loss of existing vegetation.

Vegetation maintenance activities would be implemented as described for existing facilities. Significant short-term effects from the use of this herbicide are not likely to occur, and as with existing maintenance activities, the score is 4 (Table 5-33).

Table 5-33 Vegetation Control Scores for Levee Roads for Additional Diversion Facilities

Category Score	Evaluation Category for Herbicide Use	Current Operations Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use or over water.	Co, Ch, St
3	Moderate to heavy use of herbicide approved for aquatic use or over water.	
2	Use of herbicide not consistent with instructions.	
1	Herbicide not approved for aquatic use or over water.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

5.2.6.2 Additional Distribution Facilities

Substances used for maintenance or water treatment would be the same as for existing operations. Protocols for their use and containment would be implemented in accordance with strict regulations. The risk of an accidental spill and subsequent exposure to fish in the river would be minimized by in-place and up-to-date SPCC plans.

5.3 FLOW AND ESTUARY MANAGEMENT

This section evaluates the effects of the Flow Proposal on flow, water temperature, and DO in Dry Creek and the Russian River. The Flow Proposal is designed to improve summer rearing habitat in the Russian River and Dry Creek by reducing water velocities that are currently unsuitably high. This section also assesses the effects of proposed water management on the Estuary and evaluates a proposed change in the artificial breaching program. The Flow Proposal is designed to improve summer rearing habitat in the Estuary by keeping the sandbar closed.

5.3.1 Flow Proposal

The current flow regime in the Russian River and Dry Creek is determined by the requirements of D1610. A *Flow Assessment Study* conducted jointly by SCWA, USACE, NOAA Fisheries, CDFG, and ENTRIX found that D1610 flows were higher than optimal in both streams for the rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX 2003b, Appendix F). The results of this study are provided in Appendix F. Based on the study findings and the desire to improve habitat conditions for these species, while continuing to meet regional water supply needs, SCWA has developed an alternative water management scenario called the Flow Proposal. The Flow Proposal is described in Section 4.3. Additional details on operations and proposed permit terms are provided in Appendix B.

The Flow Proposal is designed to provide improved rearing conditions by reducing flows in Dry Creek and the Russian River downstream of Coyote Valley Dam, while continuing to meet water demands for the communities served by SCWA. As the water demands increase to levels anticipated from general plans applicable to SCWA's service area, additional measures will need to be implemented to continue to provide good rearing conditions in the Russian River and Dry Creek. The "Additional Measures" are described in Section 4.3.2.4. These Additional Measures include a range of alternative actions that could be implemented to meet future water demands (at buildout) anticipated by the counties and communities within the SCWA service area, as contemplated by the WSTSP.

For purposes of this analysis, water demand at "buildout" is the amount of water that would have been delivered by SCWA assuming construction of all WSTSP facilities. As noted earlier, although it is uncertain whether the WSTSP will be carried out as described in the original WSTSP EIR, inclusion of the proposed WSTSP in the current BA allows future effects to the threatened salmonid species to be evaluated based on more specific, defined assumptions than would happen otherwise. The actual water supply facilities and diversion from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated by the WSTSP. But the inclusion of the WSTSP future water supply assumptions nevertheless provides a rough, approximate model for future analysis of effects to salmonids from future water supply development.

The Flow Proposal was evaluated using the SCWA's RRSM and RRWQM models. These models predict daily flow, temperature, and DO values at specific locations along the Russian River and Dry Creek, using a given set of starting conditions, historical and projected future demand patterns, climatic conditions, and local runoff in different watershed areas (Flugum 1996). The Russian River locations analyzed include Ukiah, Hopland, Cloverdale, Healdsburg, and Hacienda Bridge (near Guerneville). In Dry Creek, model output was analyzed in two locations: below Warm Springs Dam (Upper Dry Creek) and above the confluence with the Russian River (Lower Dry Creek). These simulations were conducted using the hydrology for the period from 1910 to 2000. Each month is assigned a water supply condition, as described under D1610 (see Section 3.4.1) based on storage levels in Lakes Pillsbury and Mendocino. Model runs were made for the Flow Proposal and D1610 under current and future (buildout) water demand levels.

5.3.2 COMPARING STREAMFLOW UNDER FLOW PROPOSAL VS. D1610

Median monthly flows and median monthly water temperatures were compared to evaluate the expected change in streamflow under the Flow Proposal. The median monthly values are the median daily flow or temperature that occurs for that month considering all of the days during the 90-year period of simulation (1910 to 2000).

The evaluation was conducted for *all* water supply conditions and for *dry* water supply conditions. *All* water supply conditions include all data regardless of the water supply category. The term "*all*" does not have a legal definition, as do "*normal*," "*dry*," and "*critically dry,"* but is the composite of all three conditions. The *all* water supply conditions are strongly reflective of *normal* water supply conditions, which occur 70 to 90 percent of the time in the months analyzed.

In this section, the *dry* water supply condition includes <u>both</u> *dry* and *critically dry* water supply conditions as defined under D1610. The values reported for the *dry* water supply condition reflect the conditions that exist only during those "*dry*" and "*critically dry*" months, and are a subset of *all* water supply conditions. These conditions occur in about 10 to 30 percent of months. *Dry* water supply conditions were used in the analysis, since water management of the system changes under these conditions and may affect salmonids differently. *Critically dry* water supply conditions were not evaluated separately because they occur infrequently, representing only 1 to 6 percent of months during the summer period.

5.3.3 COMPARING SALMONID HABITAT UNDER FLOW PROPOSAL VS. D1610

To assess effects of the Flow Proposal on salmonid habitat, conditions under the Flow Proposal were compared to the baseline (i.e., D1610) conditions. (The flows and temperatures present under D1610 are presented in Section 3.4). The evaluation criteria presented in Appendix C were used to evaluate the changes in habitat based on changes to the three parameters—flow, water temperature, and DO. Each of the parameters was scored based on the needs of the lifestage being evaluated. Scores range from 0 to 5, with 0 being the poorest and 5 being optimal. The scores are described in the text as follows: potentially lethal (0), marginal (1), poor (2), good (3), excellent (4), and optimal (5). For each species, a pie chart was prepared showing, by location and lifestage, the frequency of scores that would occur for each parameter within the appropriate range of dates for that lifestage.

In the following sections, the effects of the Flow Proposal on salmonid habitat are discussed relative to the conditions under D1610. This section describes how habitat conditions would differ under both current and buildout water supply demand levels. Because the Flow Proposal would affect flows predominantly during the summer months, the discussion focuses on the period from June through October. Flows are provided by natural rainfall patterns, and project operations have much less influence on flow levels during the winter and spring period. Potential effects during the wetter times of the year are discussed on a case by case basis when appropriate.

During June through October, the primary lifestages present in the Russian River system are rearing juvenile steelhead and coho salmon. In June, some steelhead and Chinook salmon smolts may be emigrating from the system, but most of these fish will already have passed downstream into the ocean. Small numbers of Chinook salmon adults have been observed migrating upstream as early as August under current flow and Estuary management practices. Most Chinook salmon do not begin their upstream migration until October, and under the proposed Estuary management scenario, Chinook salmon would not be able to enter the Estuary before the onset of fall rains.

The reach between Ukiah and Cloverdale provides the best mainstem habitat for salmonids (B. Cox, CDFG, pers. comm. 2001). This reach has suitable water temperatures and better channel structure (more habitat complexity) than areas downstream of Cloverdale. The water quality modeling and field data collected by SCWA indicate that water temperatures are generally too warm to provide suitable over-summer habitat for salmonids at Healdsburg and Guerneville. The mainstem Russian River above Cloverdale is used by rearing steelhead during the summer months (Cook 2003b). Coho salmon are not thought to use the mainstem except as a migration corridor to tributary streams. Steelhead also use the tributaries extensively for all lifestages. Chinook salmon use the mainstem and some of the larger tributaries for all lifestages. Chinook salmon, however, do not remain in fresh water during the summer months from July through September or October, except as noted above.

Current operations provide good water temperature conditions throughout Dry Creek for all three species. Good structural habitat is scattered throughout Dry Creek.

5.3.4 Considerations and Issues by Lifestage

5.3.4.1 Upstream Migration

Upstream migration occurs generally between September and March for the three listed species. For these species to migrate upstream successfully:

- the sandbar at the mouth of the Estuary must be open,
- the flows in the river must be high enough to supply adequate depth for fish to migrate upstream past shallow riffles, but not so high that the water velocity creates a barrier, and
- water temperatures must be suitable for the maturation of the gametes (eggs and sperm) being carried by the adults.

Chinook salmon begin migrating into the Russian River sooner than coho salmon and steelhead, with the rare individual having been observed as early as August under the current management of the system. This has made Chinook salmon the most susceptible to conditions of low flow and high temperatures during upstream migration. Under D1610, the water levels in the Estuary have been managed to prevent localized flooding along the lower river by mechanically breaching the sandbar at the mouth of the Estuary. The artificially open condition has allowed Chinook salmon to migrate upstream earlier than they could have historically, when flows and water temperatures were not suitable for upstream migration. This may have led to lowered spawning success because of longer migration times, due to delays at critical riffles because of lower flows. This would also result in additional stress on the adults and lower rates of gamete viability due to higher temperatures.

Coho salmon and steelhead begin migrating upstream in November and January, respectively. During this time, natural runoff has usually increased because the rainy season is underway, and the operation of the project reservoirs has much less influence on the flows in the mainstem. In addition, during this time, air and water temperatures have declined substantially from their summertime highs to levels that are acceptable for upstream migrants.

Mid-October Breach Under Flow Proposal

Under the Flow Proposal, the Estuary will be managed as a closed system; that is, the sandbar at the mouth of the Estuary will remain closed during the summer, as it would be naturally. With the reduced flows, the sandbar would remain closed until early storms elevated flows. If early storms did not occur, the bar would be opened when USACE begins to release water from Lake Mendocino to bring these reservoirs down to flood control levels for the winter. This typically occurs around mid-October. The closed sandbar would prevent Chinook salmon from entering the Russian River before this time. A closed Estuary would benefit Chinook salmon, because they would not be exposed to the warmer temperatures that occur before October. Also, their migration would not be delayed by the lower flows that occur in August and September, before the rainy season begins.

5.3.4.2 Spawning

Spawning typically occurs between November and March for the three species. Chinook salmon and coho salmon spawn from November into January. Steelhead spawn from January through March. The flows required for successful spawning are those that provide adequate water depths over spawning gravels, and elevated velocities to wash away fine sediments while the fish are cutting their redds (i.e., nests in the gravels where salmonids lay their eggs). The velocities should be in a suitable range to allow fish to maintain their position without exhausting themselves. A minimum of approximately 0.6-foot of depth is necessary for spawning coho and steelhead, and about 0.8-foot of depth for Chinook salmon. Water temperatures during this time of year are typically very good to excellent for spawning, although temperatures may be warmer than optimal for early spawners in some years at some locations, as discussed below.

5.3.4.3 Incubation

Considering the three species together, the incubation period extends from November into April or perhaps May. This is the period from when the first eggs are laid until the last alevin (small salmonid fry) emerges from the gravel. Flows during incubation must be sufficient to keep the redds covered with water, although the water does not necessarily have to be as deep as it was for the adults to spawn in that location. Flows must also be sufficient to provide intergravel flow (flow through the gravels) to maintain the oxygen flow to the eggs and alevins and carry waste products out of the redd. This is aided to a large extent by the locations where the fish make their redds. These are typically in areas where the hydraulics naturally tend to promote intergravel flow, such as pool tailouts and riffles. Flows must not be so high as to scour the redds.

Water temperatures in the mainstem Russian River above Cloverdale are generally very good for incubation in *all* water supply conditions, although redds created in October may be exposed to very stressful water temperatures in the Upper Russian River. In *dry* water supply conditions, water temperatures are a little warmer, but would still provide good conditions in the mainstem above Cloverdale (although October water temperatures would still be quite warm). Alevins that stay in the redds until late April or May may be exposed to warmer-than-optimal temperatures above Cloverdale. Water temperatures in Dry Creek below Warm Springs Dam are generally good for incubation throughout the season, and, in Dry Creek above the Russian River, temperatures are good into May under both water demand scenarios.

5.3.4.4 Summer Rearing

This lifestage extends over the warmer portion of the year from June through October. This is the season when project operations predominantly affect flow conditions within the Russian River downstream of the Forks and in Dry Creek. Summer rearing applies to steelhead and coho salmon in their first year of life. The juveniles of these species spend one year or more in fresh water before emigrating to the ocean. This lifestage does not apply to Chinook salmon because Chinook salmon fry begin emigrating to the ocean within a few weeks of emerging from the gravel. Some Chinook salmon may still be in the river in June, but by the end of June, all have migrated downstream.

As previously discussed, the *Flow Assessment Study* (ENTRIX 2003b, Appendix F) conducted jointly by SCWA, NOAA Fisheries, CDFG, USACE, and ENTRIX found that D1610 flows in the Russian River and Dry Creek were higher than optimal for rearing salmonids. Because of this, both high temperatures and high flows are major concerns when evaluating the effect of flows on this lifestage.

5.3.5 CHANGES IN FLOW AND TEMPERATURE

The changes in flow and temperature described below are based on the median monthly flow and water temperature values, as determined from the daily flow and mean daily water temperatures estimated by the model. The median monthly values for flow and temperature for D1610 are shown in Tables 3-8 and 3-9, respectively. For the Flow Proposal, median monthly flow values are shown in Table 4-5, and median monthly temperature values are shown in Table 5-34. The median monthly values provide an index as to how the flows change from month-to-month and the flow value expected in a given month. They do not describe the complete range or distribution of flows and temperatures.

In evaluating D1610 and the Flow Proposal, the evaluation criteria were applied to each parameter for each day at each location. The frequency of scores is based on the entire record and describes the range of flow and water temperature values observed. Thus, the median flow may lead one to expect a particular score during a month, but the actual score may differ depending on how the full range of flows or temperatures is distributed.

Table 5-34 Median Monthly Temperature (°C) Values Under the Flow Proposal

***All* Water Supply Conditions**												
Stations	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ukiah	8.5	9.2	11.3	12.6	14.5	16.3	16.2	17.6	18.5	18.8	15.1	10.7
Hopland	8.5	9.4	11.7	13.4	16.1	18.5	19	19.7	19.5	18.7	14.9	10.6
Cloverdale	8.4	9.4	11.9	14	17	19.4	20.3	20.6	19.8	18.4	14.7	10.4
Healdsburg	8.5	9.8	12.6	15.6	19	21.8	23.8	23.5	21.6	18.5	14.2	10.1
Below Dry Creek	8.9	10.1	12.7	15.5	18.8	21.4	22.8	22.2	20.5	17.8	13.9	10.4
Hacienda	9	9.9	12.2	15	18.3	21.3	23.9	24	22.2	18.6	14.1	10.5
Warm Springs Dam	12.4	11.8	12.8	12.9	13.1	13.2	13.3	13.2	13.1	12.9	12.7	12.7
Lower Dry Creek	10.4	11	13	14.7	17	18.3	18.7	18.2	17	15.6	13.1	11.6

***Dry* Water Supply Conditions**												
Stations	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Ukiah	9.4	9.5	11.4	13	14.3	15.2	16.2	19.5	21.6	19.5	14.8	10.8
Hopland	9.6	9.7	11.9	14.3	16	17.6	18.6	20.6	21.2	19	14.5	11
Cloverdale	9.6	9.7	11.9	14.7	16.8	18.7	19.8	21	20.7	18.6	14.5	10.7
Healdsburg	9.4	10	12.7	16.1	19.2	21.5	23.7	23.1	21.4	18.6	13.9	10.1
Below Dry Creek	9.9	10.2	12.8	15.9	18.8	20.9	22.2	21.8	20.1	17.6	13.5	10.2
Hacienda	9.6	10	12.2	15.1	18.5	21.7	24.4	23.7	21.9	19	13.6	10.4
Warm Springs Dam	12.7	12.6	12.8	13	13.1	13.2	13.1	13.1	13	12.9	12.8	12.7
Lower Dry Creek	11.3	11.3	12.9	15.1	16.9	17.7	18.1	17.8	16.8	15.4	13.1	11.4

5.3.5.1 Flow

The *Flow Assessment Study* (ENTRIX 2003b, Appendix F) concluded that habitat for rearing salmonids could be improved if flows were reduced from levels that occur under D1610. This conclusion was reached for the mainstem from the Forks to Cloverdale and in Dry Creek. As described below, the Flow Proposal would reduce flows substantially compared to current operations under D1610, in order to improve rearing habitat.

Russian River

At Ukiah under *all* water supply conditions, median flows during the summer months (June through October) under D1610 range from about 260 cfs in July to about 175 cfs in September-October under current demand levels. Under the Flow Proposal, flows would drop to about 185 cfs in June and 130 cfs in October (Figure 5-3). During November through May, flows would be similar under the Flow Proposal and D1610, ranging from a median monthly flow of about 170 cfs in November to 925 cfs in February. Flows would differ by a maximum of about 11 percent during this time period.

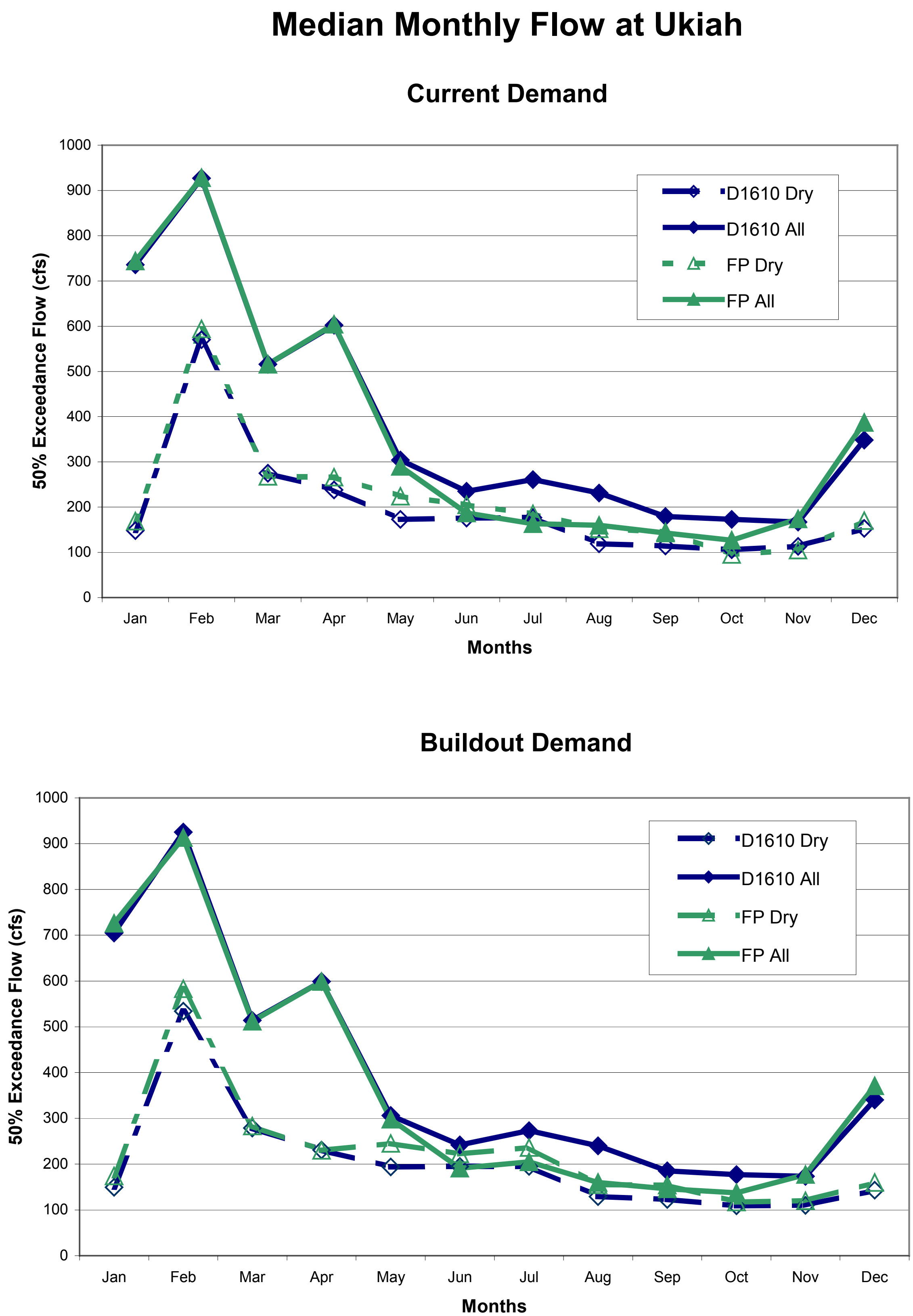


Figure 5-3 Median Monthly Flows in the Russian River at Ukiah under D1610 and the Flow Proposal

At Ukiah, under *dry* water supply conditions, the Flow Proposal median flows would range between 95 and 205 cfs during the June-October time frame, an increase of 5 to 30 cfs relative to D1610, except in October when flows would be about 10 cfs lower. During November through May, flows would be similar under the Flow Proposal and D1610, ranging from a median monthly flow of about 105 cfs in November to 595 cfs in February. The maximum differential between the two management scenarios would again be about 11 percent.

At Ukiah, under *all* water conditions, the Flow Proposal would provide flows 40 to 80 cfs lower than D1610 during June through October at buildout. Flows during this time frame would range from about 180 to 275 cfs under D1610 and from 135 to 205 cfs under the Flow Proposal (Figure 5-3). The Flow Proposal would provide flows 10 to 30 cfs higher at buildout than at current demand levels. These flows would remain lower than those that currently occur under D1610. Flows during November and May would be similar for the two management scenarios and would be about the same as under current demand levels.

Under *dry* water supply conditions, the Flow Proposal would result in flows 10 to 40 cfs higher than D1610 at buildout. This would occur because the Flow Proposal balances water supply from the two reservoirs differently than under D1610, to maximize habitat value in the Russian River and Dry Creek. Flows during November through May would be similar under the Flow Proposal and D1610, differing by a maximum of 5 percent in January.

The relative differences in flow in the Russian River would persist under both *all* and *dry* water supply conditions and in both demand scenarios. Under *all* water supply conditions, at both demand levels, flows tend to increase with distance downstream from Coyote Valley Dam to Healdsburg from November through May, and decrease with distance downstream from the dam from July through September. Flows are relatively constant throughout this reach in June and October. Under *dry* water supply conditions for both demand levels, this pattern is similar, except that flow decreases with distance downstream in June. Below Healdsburg, flows from Dry Creek enter the river, increasing flows downstream as far as the Mirabel diversion facilities, where SCWA rediverts water released from the reservoirs to meet water supply needs. The pattern of increasing or decreasing flows resumes below Mirabel.

Dry Creek

Summer flows in Dry Creek would be reduced by the Flow Proposal as well. At current demand levels for *all* water supply conditions, flows under D1610 range from about 80 to 105 cfs between June and October (Figure 5-4). Under the Flow Proposal, corresponding flows would range from about 55 to 75 cfs in the June-October time frame. Under *dry* water supply conditions, flows would increase over *all* water supply conditions for both scenarios. At buildout under D1610, flows would increase to range between 90 and 140 cfs for *all* water supply conditions and to 125 to 235 cfs under *dry* water supply conditions. Under the Flow Proposal, the flow increase would be much less, ranging from 55 to 90 cfs for *all* water supply conditions and 65 to 100 cfs for *dry* water supply

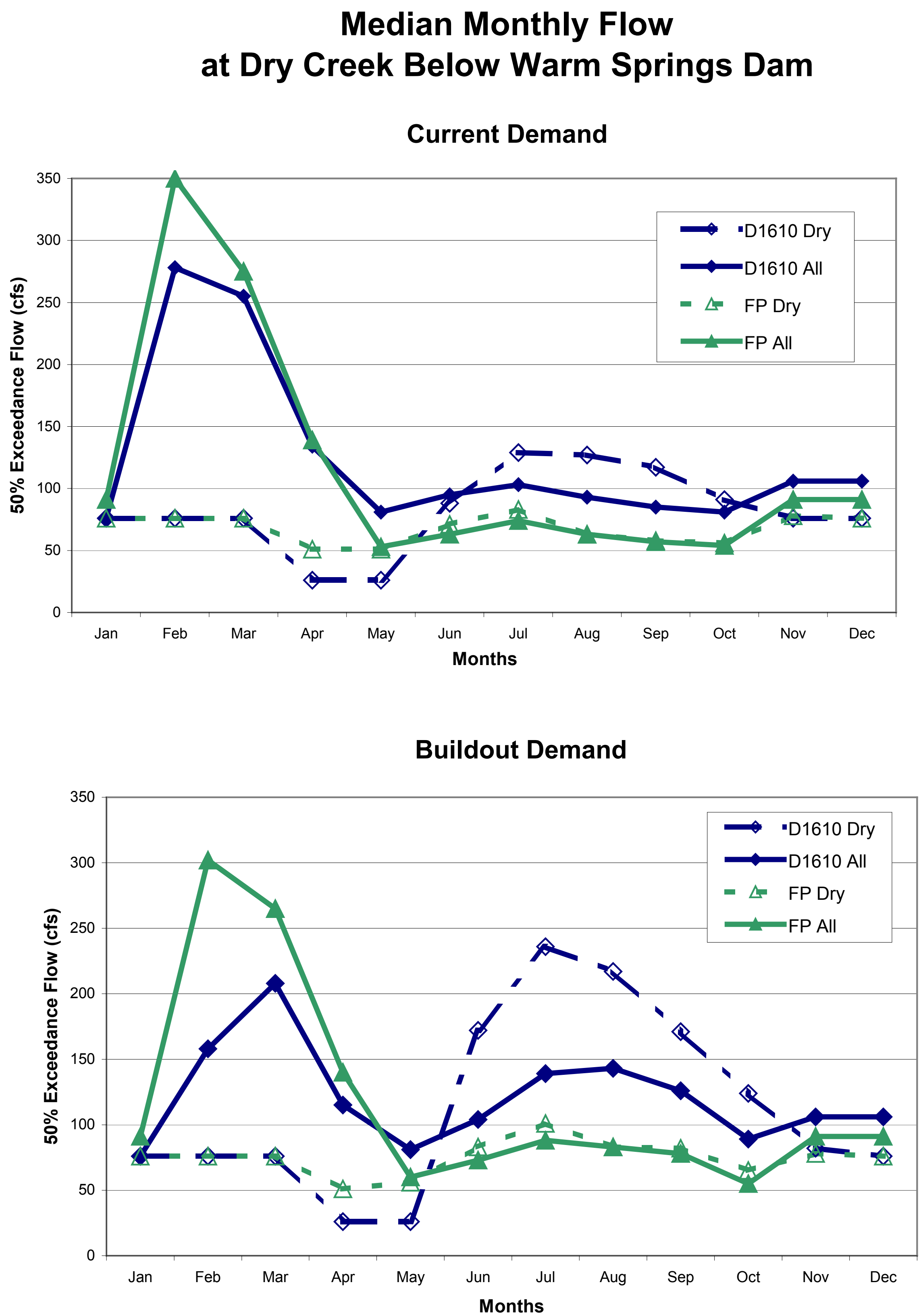


Figure 5-4 Median Monthly Flows in Dry Creek Below Warm Springs Dam under D1610 and the Flow Proposal

conditions. Under the Flow Proposal in *critically dry* water supply conditions (which occur only 2 percent of the time in summer) flow in Dry Creek would be much higher, ranging from 140 to 200 cfs. These flow conditions would severely reduce rearing habitat in Dry Creek, but are lower than what occurs under D1610 under dry water supply conditions, which occur six times more frequently.

Flows in Dry Creek during February and March (and to a lesser extent in January) would tend to be higher under the Flow Proposal than under D1610. This would occur because the lower summer flows would leave more water in the flood control pool at the end of the year. Thus, USACE would have to make larger releases during the runoff period to keep the reservoir level within the flood control pool. These larger flows would occur under both *all* and *dry* water supply conditions. Under *all* water supply conditions and current demand levels, flows in February and March would be 350 and 275 cfs, respectively, under the Flow Proposal, and 278 and 255 cfs, respectively, under D1610. Under *all* water supply conditions at buildout demand levels, flows in February and March would be 302 and 265 cfs, respectively, under the Flow Proposal, and 158 and 208 cfs, respectively, under D1610. Under *dry* water supply conditions, flows under the two management strategies would be similar during these months, about 75 cfs during both current and buildout demand levels. The Flow Proposal has higher flows than D1610 in April and May in *dry* water supply conditions, with flows of about 50 cfs, as opposed to 25 cfs under D1610.

5.3.5.2 Temperature

The changes in flow under the Flow Proposal will affect water temperatures. Lower flows generally result in higher water temperatures in the summer months. However, lower flows also decrease the rate at which the coldwater pool at the bottom of Lake Mendocino is depleted. This is seen in the pattern of temperatures in the mainstem Russian River below the dam. At Ukiah, under the Flow Proposal at current demand levels, water temperatures are warmer than under D1610 in June and July, but by less than 0.5°C, and cooler than D1610 during September and October, by as much as 2°C (Figure 5-5). In June and July, the lower temperatures occur because the lower flows under the Flow Proposal respond more quickly to ambient air temperatures than the larger volume of water under D1610. In September and October, the cooler temperatures occur because the large flows under D1610 drain the coldwater pool at the bottom of Lake Mendocino more quickly. This coldwater pool is depleted in September, and releases after this date reflect the warmer temperatures of the water flowing into Lake Mendocino. With the lower flows under the Flow Proposal, the coldwater pool is not depleted as quickly and cool water is available for release through September and into October, when ambient air temperatures begin to decline.

The difference in water temperature between D1610 and the Flow Proposal diminishes with distance downstream, with a maximum difference at Hopland of less than 1.5°C, and less than 0.5°C at Cloverdale. Further downstream at Healdsburg, the water temperatures under D1610 and the Flow Proposal are nearly identical. Below the confluence of Dry Creek and at the Hacienda Bridge, the Flow Proposal results in summer temperatures that are generally less than 0.5°C warmer than under D1610. These

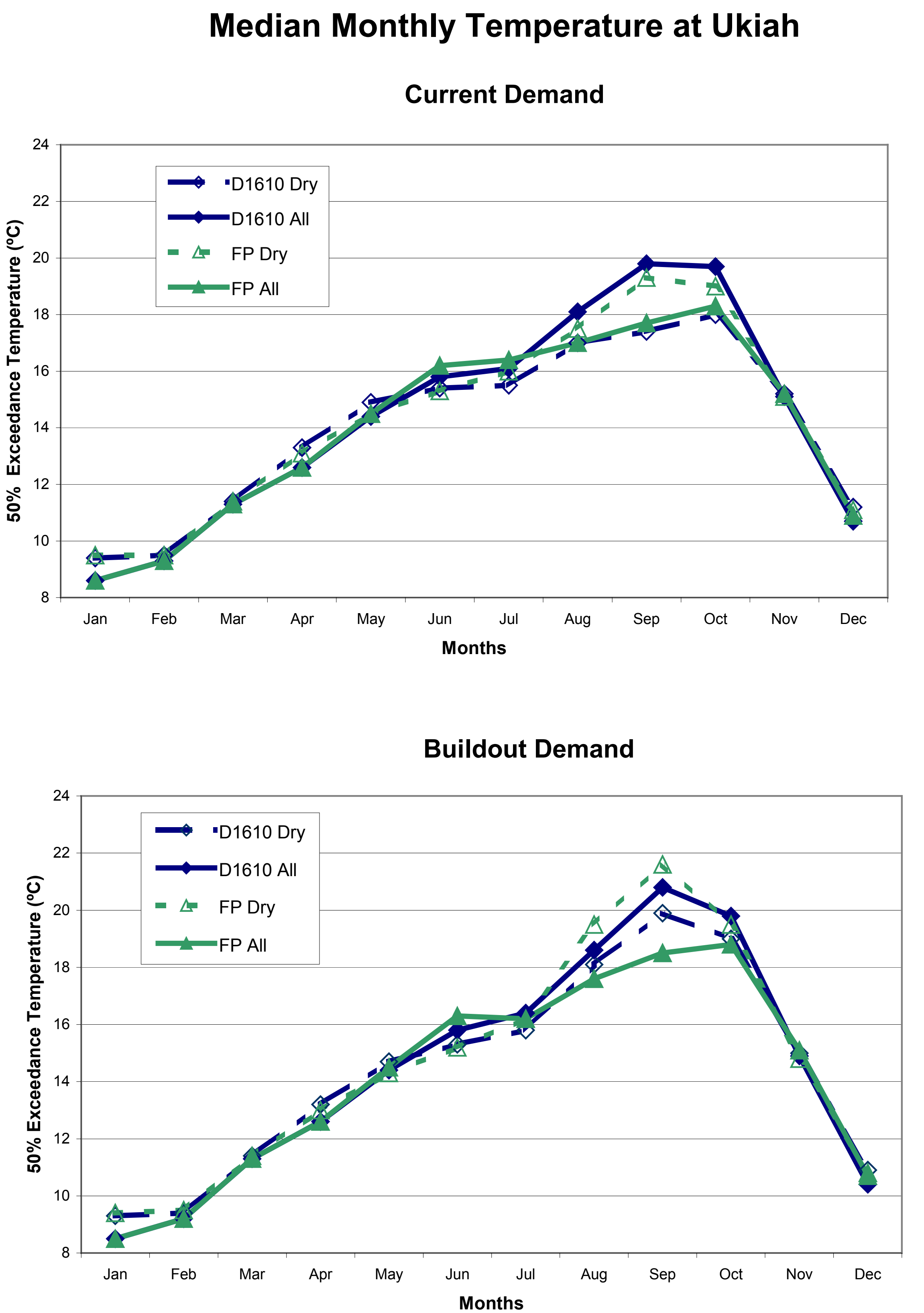


Figure 5-5 Median Monthly Temperatures in the Russian River at Ukiah under D1610 and the Flow Proposal

distance downstream, for both water supply conditions, as observed under the current demand scenario.

During November through May, water temperatures on the mainstem Russian River are similar for the Flow Proposal and D1610 regardless of water supply condition or demand level.

Temperatures in Dry Creek are determined by releases from Warm Springs Dam. These releases are made to meet the needs of DCFH and therefore, are near optimal for salmonids. Near the dam, water temperatures are nearly identical between D1610 and the Flow Proposal under both water supply conditions and both demand levels. Temperature differences occur as the water moves downstream and is subjected to ambient air temperatures. The smaller volume of water released under the Flow Proposal results in water temperatures in the downstream end of Dry Creek that are as much as 1°C warmer than D1610 under *all* water supply conditions and 1.5°C warmer under *dry* water supply conditions, at current demand levels (Figure 5-6). The highest median monthly temperature simulated under the Flow Proposal is 18.9°C. This is well within the appropriate range for rearing steelhead (temperatures up to 20°C are scored as good), but is somewhat stressful for coho salmon. D1610, with a corresponding temperature of 17.9°C, would also receive a score of 2 for coho rearing.

Dry Creek water temperatures between November and April are very similar for D1610 and the Flow Proposal under both *all* and *dry* water supply conditions and both demand scenarios.

5.3.6 Flow-Related Habitat

In the subsequent sections, the Upper Russian River (above Cloverdale) and Dry Creek are discussed more fully than the other reaches because of their importance to salmonid spawning and rearing. Salmon and steelhead use the Russian River downstream of Cloverdale primarily for passage between the ocean and freshwater spawning and rearing habitat. Some spawning by Chinook salmon has been documented further downstream and limited steelhead rearing may occur into the Middle Russian River (Section 2.2.3 and 2.2.4). Flow and water temperatures varies among the reaches and throughout the year. DO is generally favorable for salmonids in all the reaches and very rarely reaches stressful levels. The criteria used to evaluate the effects of flow on all species and lifestages are based on current channel morphology and associated levels of cover, refuge habitat, feeding areas, etc. In the sections that follow, the flows are assumed to vary as described above, but the channel structure is assumed to be constant. The discussion of flow related habitat focuses primarily on the changes in depth and velocity that would occur, and to a lesser extent, on stream width and the proximity of the water to bank structures and vegetation that contribute to overall habitat value.

5.3.7 Coho Salmon

Coho salmon use tributary habitat for rearing and spawning and use the Russian River for passage. The Flow Proposal could affect coho salmon migration in the mainstem Russian

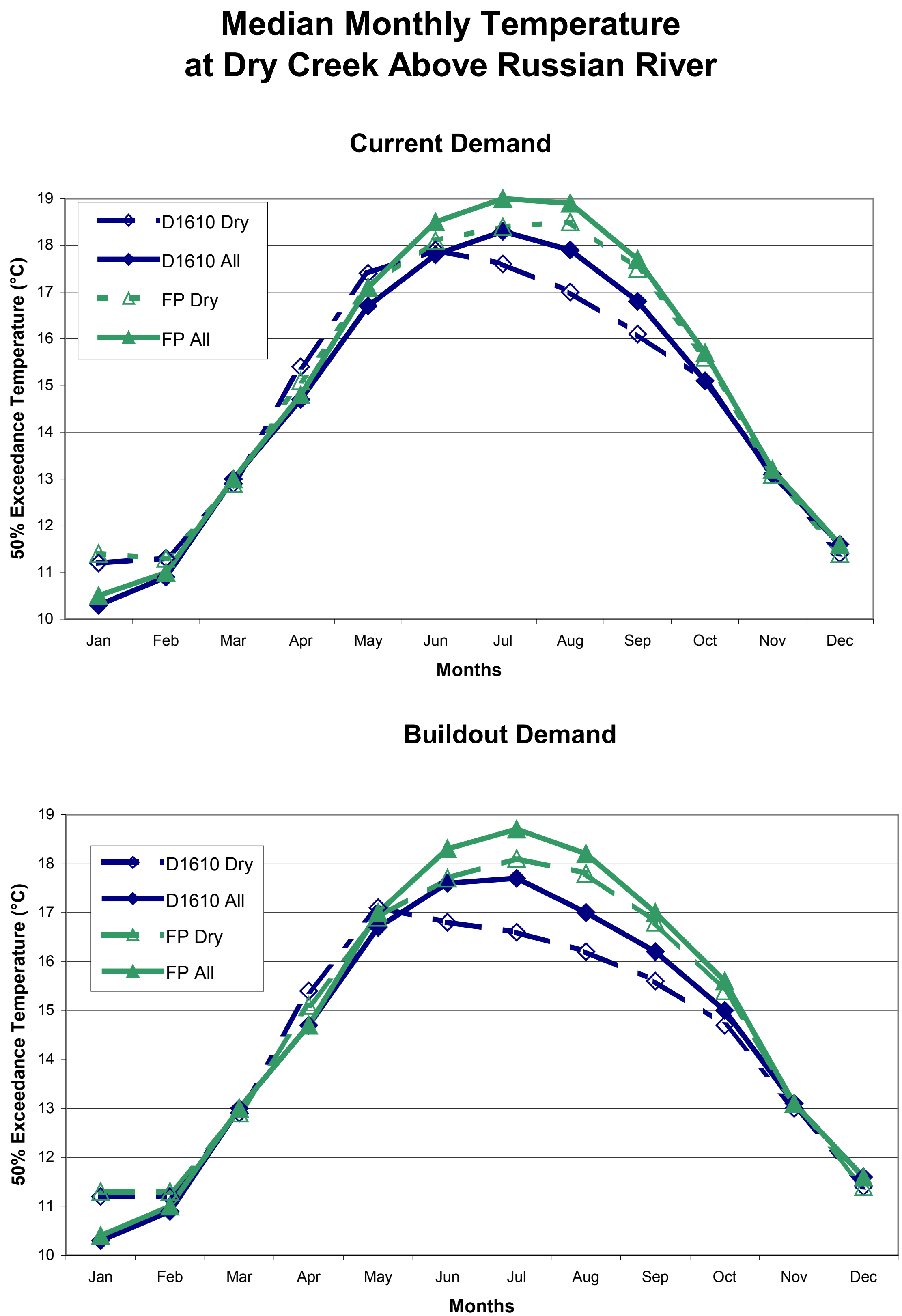


Figure 5-6 Median Monthly Temperatures in Dry Creek above the Russian River under D1610 and the Flow Proposal

River and rearing, migration, and spawning in Dry Creek. The Flow Proposal could change flow-related habitat, water temperatures, and DO. The most important changes would occur to flow and water temperatures. Model results indicate extremely minor changes in DO, none of which would adversely affect coho salmon. The following discussion describes the changes to coho salmon habitat from changes in streamflow and water temperature by river reach.

5.3.7.1 Russian River Flow

Upstream Migration

Coho salmon can migrate upstream in the Russian River at flows of 100 to 2000 cfs (Appendix C). Flows lower than 100 cfs may slow or impede fish migration, and passage may not be possible below 50 cfs. The upstream migration period for coho salmon is November through January. During this period, the Flow Proposal and D1610 would provide similar flows and similar levels of habitat (Figure 5-7).

At Ukiah under the Flow Proposal for *all* water supply conditions, median flows would range from about 170 cfs (November) to 740 cfs (January), and at the Hacienda Bridge from approximately 310 cfs to 2,690 cfs for the same months. Most coho salmon use streams in the Lower Russian River such as Green Valley, Freezeout, and Mark West creeks. Flows in the Lower Russian River from Healdsburg to Hacienda Bridge would provide good migration conditions during most of the migration period.

Under the Flow Proposal, migration flows scored a 3 or greater 73 percent of the time under *all* water supply conditions for both current and future demand levels. Scores less than 3 are due to higher-than-optimal flows throughout the migration period in the Lower Russian River and lower-than-optimal flows in the Upper mainstem during November and December. These scores are almost identical to those assigned to the same locations under D1610. The good passage scores for D1610 indicate that passage conditions are generally suitable when coho salmon are migrating in the mainstem and should be able to reach tributary habitat.

Under *dry* water supply conditions, flows would be lower, ranging from 105 to 169 cfs at Ukiah and from 169 to 767 cfs at the Hacienda Bridge. These flows would provide acceptable passage flows for coho salmon 65 percent of the time (Figure 5-9). Passage may be slowed or impaired 34 percent during *dry* water supply conditions, but flows would not drop low enough to prevent passage. Under D1610, flows for *dry* water supply conditions are similar and provide similar passage opportunities.

For future demand conditions, flows would be slightly higher for both *all* and *dry* water supply conditions, but passage opportunities for coho salmon would stay the same (Figures 5-8 and 5-10).

5.3.7.2 Russian River Water Temperatures

Because coho salmon are migrating in the winter months, water temperatures during the migration period are generally suitable. Water temperatures from 6.0 to 14.0°C provide good-to-excellent conditions for upstream migrants. Under the Flow Proposal under current demand levels, the Lower Russian River at Hacienda and at Healdsburg would have median monthly water temperatures near 14°C in November to 9°C in January. Water temperature scores for the lower river stations would be in the suitable range 91 percent of the time (Figure 5-11). At times, warmer water temperatures have occurred, contributing to scores of 1 or 2 for 9 percent of the time. Low scores are generally due to warmer water temperatures that occur in November in some years. Under D1610 water temperatures are similar to those that would occur under the Flow Proposal.

Under the Flow Proposal for *dry* water supply conditions under current demand level, the water temperatures would remain suitable approximately 90 percent of the time in the areas where coho salmon currently migrate (Figure 5-12). Further upstream, water temperatures warm slightly, but suitable water temperatures would still be available 80 percent of the time.

Under the Flow Proposal, the water temperature during the coho migration period would be similar to those provided under D1610 for both *all* and *dry* water supply conditions at buildout (Figures 5-13 and 5-14).

5.3.7.3 Dry Creek Flow

Juvenile Rearing

The following analysis focuses on flow-related habitat. In general, other coho habitat features are lacking in Dry Creek. Implementation of the Flow Proposal in conjunction with the placement of habitat improvement structures (evaluated in Section 5.5.3.1) is likely to create suitable habitat conditions for coho salmon juvenile rearing.

Juvenile coho salmon rearing conditions in Dry Creek vary with flow. Excellent-to-optimal habitat conditions are present at flows between 45 cfs and 100 cfs. Suitable habitat conditions for juvenile coho salmon span flows from 25 to 120 cfs (Appendix C). The Flow Proposal would provide excellent-to-optimal summer (June through October) rearing conditions throughout Dry Creek. In the reach below Warm Springs Dam, scores of 4 or more would be present 78 percent of the time and 85 percent of the time in the reach above the mouth (Figure 5-15). The lower flows afforded by the Flow Proposal would provide substantially better conditions than D1610 flows.

Under D1610, excellent-to-optimal habitat conditions are provided only 69 and 79 percent of the time in the two reaches (from upstream to downstream) at current demand levels. The Flow Proposal's benefits under future demand for *all* water conditions are even more apparent (Figure 5-16). Under D1610 at buildout demand levels, excellent-to-optimal habitat conditions are provided only 25 and 33 percent of the time in the two reaches (from upstream to downstream). Poor habitat conditions (scores of 2 or less) resulting from high flows and high velocities would occur 56 and 44 percent of the time, respectively.

Flow Proposal flows for *dry* water supply conditions would be similar to *all* water supply conditions for current demand. Summer rearing conditions would be suitable (scores of 3 or greater) 90 to 95 percent of the time throughout Dry Creek (Figure 5-17). Under the Flow Proposal at buildout, higher flows would be released and rearing conditions would decline below Warm Springs Dam. However, excellent-to-optimal rearing conditions would occur 75 to 80 percent of the time, for both *dry* and *all* water supply conditions, respectively (Figures 5-16 and 5-18). These lower scores would result from more frequent high flows. In contrast, under D1610 at buildout demand levels, flows would provide suitable rearing conditions less than 25 to 30 percent of the time under *dry* and *all* water supply conditions.

Given that summer rearing often limits coho salmon production in freshwater streams (Nickelson and Lawson 1998), the Flow Proposal should increase the quality and quantity of coho salmon summer habitat in Dry Creek. This would be beneficial for the recovery of coho salmon stocks in the Russian River.

Upstream Migration

In Dry Creek, flows from 30 to 325 cfs provide suitable conditions for coho salmon migration. Flows below 30 cfs may slow or impede migration, and flows below 10 cfs would likely block migrations (Appendix C). Under the Flow Proposal, flow would provide excellent-to-optimal conditions (scores of 4 or greater) 72 percent of the time below Warm Springs Dam and 68 percent of the time in Lower Dry Creek (Figure 5-15). This would be an improvement in passage conditions below Warm Springs Dam when compared to D1610 flows where scores of 4 or greater only occur 55 percent of the time. About 10 percent of the time passage is impeded or blocked and scores are zero for both water management scenarios. In Lower Dry Creek, flow conditions are similar for both water management scenarios, due to the influence of tributary inflow, which is significant at this time of year. In Lower Dry Creek, conditions tend to be slightly less favorable for upstream migration than at the upstream end of Dry Creek because flows tend to be higher than optimal. Low upstream migration scores in Lower Dry Creek are almost always associated with flows that are higher than optimal.

Similar patterns were evident between the Flow Proposal and D1610 for flows under the buildout demand level as those found for current demand levels (Figure 5-16).

Under *dry* water supply conditions, the Flow Proposal and D1610 would provide similar flows for migrating adults (Figures 5-17 and 5-18). Because flows are higher under *dry* conditions in Dry Creek, passage scores are not as good as under *all* water supply conditions. Scores remain predominantly suitable, with 91 percent of the flows assigned a score of 3, but only 2 percent warranting a score of 4 or more. There were only a small percentage of days (5) where passage scored less than 3.

Overall, the Flow Proposal would provide better upstream migration flow than D1610 for coho salmon in Dry Creek under current and buildout water demands. The largest improvement would occur in the Upper Reach.

Spawning

Flows supporting excellent-to-optimal habitat for spawning coho salmon range from 45 to 100 cfs (Appendix C). Under the Flow Proposal, conditions for coho spawning would improve compared to D1610 for *all* water supply conditions (Figure 5-15). For the reach below Warm Springs Dam, the model predicts that 68 percent of daily flows under the Flow Proposal would receive a score of 4 or greater compared to only 44 percent of the flows under D1610. In Lower Dry Creek, the Flow Proposal and D1610 are similar. The Flow Proposal would provide excellent-to-optimal conditions only 20 percent of the time and poor conditions (scores less than 2) about 40 percent of the time. High flows are usually associated with low scores in this reach.

For buildout demand conditions, the Flow Proposal would provide more spawning habitat in the reach below Warm Springs Dam than D1610. Excellent-to-optimal spawning habitat would be present 70 percent of the time compared to 46 percent of the time under D1610. Spawning conditions in the Lower Reach are similar in both the Flow Proposal and D1610 and have a higher proportion of low scores due to high flows.

Under the Flow Proposal, spawning conditions would improve under *dry* water supply conditions throughout Dry Creek (Figures 5-17 and 5-18). Also under the Flow Proposal, the percentage of flows that are excellent to optimal for coho salmon spawning would increase from 20 to 25 percent relative to D1610 under *all* water supply conditions. Under *dry* water supply conditions and buildout demand levels, the Flow Proposal would provide lower flows than D1610. As shown in Figure 5-18, D1610 provides less favorable spawning conditions under buildout demand than the Flow Proposal in the lower portion of Dry Creek. Very good-to-excellent habitat would be available 45 percent of the time with the Flow Proposal and 33 percent of the time under D1610. Both the Flow Proposal and D1610 are similar below Warm Springs Dam and would provide excellent spawning conditions approximately 90 percent of the time.

Incubation

The Flow Proposal would provide conditions for coho salmon during the incubation period (December 1 to March 30) similar to those available under D1610. Excellent-to-optimal incubation conditions would be present approximately 60 percent of the time for *all* water supply conditions under current demand levels (Figure 5-15). At buildout demand levels there is no real difference between the D1610 and the Flow Proposal throughout Dry Creek (Figure 5-16). Thus, it is unlikely that the Flow Proposal would significantly affect coho incubation relative to D1610.

In Lower Dry Creek under *dry* water supply conditions and current demand levels, the Flow Proposal would produce excellent-to-optimal incubation conditions about 80 percent of the time below Warm Springs Dam, and about 50 percent of the time in Lower Dry Creek. D1610 provides similar conditions (Figure 5-17). The Flow Proposal would produce a few more days (4 percent more) with lower scores in the reach below Warm Springs Dam than D1610 does. This pattern is evident under buildout demand levels as well (Figure 5-18).

Water Temperature

The temperatures for *all* water supply conditions in Dry Creek under the Flow Proposal are generally suitable for all lifestages of coho salmon (Figure 5-19). Daily temperatures would provide excellent-to-optimal habitat conditions over 90 percent of the time (scores of 4 more for all lifestages and reaches) except summer rearing in Lower Dry Creek. Here, higher than optimal temperatures would be stressful for juveniles 90 percent of the time. This occurs for both water management scenarios, although D1610 is expected to provide good rearing temperatures (score of 3 or more) 20 percent of the time. Median daily temperatures during the summer in Lower Dry Creek are generally 17^{o}C to almost 18^{o}C. Water temperatures greater than 16^{o}C are stressful for coho salmon.

Under the Flow Proposal, water temperatures under buildout demand levels would be similar to those under current demands (Figure 5-20). There is a small improvement in water temperatures due to higher flows. This pattern is evident under D1610 as well. Under the buildout demand level, D1610 provides slightly better water temperatures in Lower Dry Creek. *Dry* water supply conditions under current and buildout demand levels show the same patterns. Water temperatures under the Flow Proposal and D1610 would be excellent to optimal in Upper Dry Creek and stressful in Lower Dry Creek (Figures 5-21 and 5-22). D1610 provides slightly better thermal conditions in Lower Dry Creek.

5.3.7.4 Summary

Coho salmon predominately use the mainstem Russian River as a migration corridor. In the Russian River, the Flow Proposal would provide similar conditions for adult migration as D1610. Flows during this time of year are controlled primary by natural runoff and rainstorms. Flows are predicted to provide good to optimal migration conditions about 75 percent of the time for *all* water supply conditions and 65 percent of the time for *dry* water supply conditions, reflecting the lower flows during migration periods. These results are consistent for both current and buildout demand levels. Model results for water temperature indicate that conditions are generally suitable for coho salmon in the Russian River, as daily temperatures were suitable for adult migration over 90 percent of the time.

Coho salmon may use Dry Creek for spawning and rearing. Implementation of the Flow Proposal in Dry Creek would primarily benefit rearing juveniles. As rearing habitat is thought to be the limiting factor for coho salmon in the Russian River watershed, improvements in summer rearing conditions could help coho recolonize Dry Creek and its tributaries. The Flow Proposal would provide good to optimal rearing flows 90 to 95 percent of the time under *all* and *dry* water conditions, while suitable flows under D1610 management occur about 10 percent less often. Under buildout conditions, the Flow Proposal would provide suitable rearing flows much more frequent than D1610, assuring that juvenile coho salmon would continue to survive in Dry Creek as demand levels increased.

The Flow proposal should also improve conditions for upstream migration and spawning in upper Dry Creek and provide similar conditions to D1610 in lower Dry Creek. Both water management scenarios are predicted to provide similar conditions for incubation. Water temperatures are also similar for the Flow Proposal and D1610 and are generally suitable for all life history stages.

5.3.8 STEELHEAD

Steelhead use habitat throughout the Russian River watershed. They use the Lower Reach of the Russian River predominantly as a migration corridor. The Upper and Middle Reaches of the Russian River provide spawning and rearing habitat. Steelhead use many of the tributaries for spawning and rearing, including Dry Creek, and may use the Estuary for rearing as well, when conditions are suitable. The Flow Proposal would change habitat conditions in the Russian River downstream of Coyote Valley Dam to the Estuary and in Dry Creek below Warm Springs Dam to the mouth. The changes that would occur under the Flow Proposal in flow and water temperature and the associated effects on steelhead habitat are discussed below.

5.3.8.1 Russian River Flow

The Flow Proposal would provide flow levels that improve summer rearing flows for steelhead in the Russian River mainstem, relative to baseline conditions. The lower flows provided under the Flow Proposal would provide cooler water temperatures in the Upper Russian River during September and October, with a smaller reduction in August. In the Middle and Lower Reaches of the Russian River, small increases in water temperatures would occur. From November through May, flows in the Russian River would be similar to the D1610 watershed because runoff has a greater influence on the flow patterns than water releases from the reservoirs.

Juvenile Rearing

The Flow Proposal is structured to provide lower flows in the Russian River to improve summer habitat conditions (June through October) for rearing fish. The best rearing habitat in the Russian River is located between Ukiah and Cloverdale. Median summer flows under the Flow Proposal for *all* water supply conditions would range from a high of approximately 180 cfs in June, down to 130 or 140 cfs in October for these locations. Median flows under the Flow Proposal are predicted to be from 45 to 100 cfs lower in the Russian River at Ukiah, Hopland, and Cloverdale compared to D1610 during the summer rearing period (Tables 3-8 and 4-5).

Summer rearing flows under the Flow Proposal would provide lower water velocities in riffles and runs where steelhead juveniles prefer to rear. Daily flow scores for *all* water supply conditions during June through October predict that conditions for rearing would be excellent or optimal 64 to 70 percent of the time depending on location. Cloverdale would have more days scoring 4 or 5 than either Ukiah or Hopland. Under D1610, optimal-to-good rearing conditions are provided only 35 to 40 percent of the time (Figure 5-23). From Ukiah to Cloverdale, the Flow Proposal would provide excellent-to-optimal habitat conditions (scores of 4 or more) for steelhead rearing 58 to 71 percent of the time under buildout demand levels. The higher flows reduce the number of days with optimal scores at Ukiah and Hopland, but Cloverdale scores remain high (Figure 5-24).

During *dry* water supply conditions, median flows would be as much as 30 to 40 cfs higher under the Flow Proposal compared with D1610. Under the Flow Proposal, excellent-to-optimal rearing habitat would be provided 64 to 71 percent of the time, with the highest habitat scores found at Cloverdale (Figure 5-25). Under *dry* water supply conditions, D1610 provides slightly better flow conditions for rearing, with daily flows receiving scores of 4 or greater 10 percent more frequently than the Flow Proposal. Both management scenarios would provide suitable conditions for rearing (scores of 3 or higher) about 90 percent of the time throughout the mainstem, with stressful flow conditions occurring about less than 10 percent of the time.

Under *dry* water supply conditions at buildout (Figure 5-26), scores for the Flow Proposal and D1610 would be better than those for *dry* water supply conditions at current demand levels. D1610 would provide somewhat better conditions than the Flow Proposal.

Upstream Migration

Steelhead migrate up the Russian River mainly during the period January through March depending on storm activity. As described previously, flows are largely governed by uncontrolled runoff from the watershed, rather than the operation of the dams. Flows that provide suitable passage in the Russian River range from 100 to 2000 cfs (Appendix C). Flows are normally in this range during much of the migration period. Higher flows occur more frequently in the lower portion of the river (below Dry Creek and at Hacienda). Under the Flow Proposal under *all* water supply conditions, daily flows during the upstream migration season would range from about 500 to 1400 cfs between Ukiah and Cloverdale, and between 2600 and 3900 cfs at Hacienda Bridge.

Throughout the mainstem, the Flow Proposal would provide good conditions (scores of 3 or greater) for steelhead upstream migration 65 to 75 percent of the time under both current and buildout demand levels, and excellent conditions 25 to 50 percent of the time (Figures 5-23 and 5-24). Flow scores are somewhat lower for the downstream locations, due to accretion that occurs with distance downstream. Flows greater than 2,000 cfs or less than 100 cfs may begin to impair upstream passage for steelhead. These conditions occur about 25 to 30 percent of the time upstream of Cloverdale, and 30 percent of the time at Healdsburg. This impairment is largely due to high flows, although low flows that can impede passage occasionally occur.

Under *dry* water supply conditions, the Flow Proposal and D1610 would provide similar flows during the steelhead upstream migration period. In general, conditions for migrating adults are better under *dry* water supply conditions and improve upstream from Healdsburg. This is due to a reduced frequency of high flows, which results in a greater frequency of scores of 4 or 5. Good habitat conditions for upstream passage are provided about 70 to 75 percent of the time at Ukiah, Hopland, and Healdsburg (Figure 5-25). Slightly improved levels of upstream passage would be available under both water management scenarios at buildout (Figure 5-26).

Spawning

Steelhead spawning occurs from January through April in the Upper Russian River near Ukiah, Hopland, and Cloverdale. In this reach, flows from 100 to 350 cfs provide good habitat conditions for spawning steelhead (Appendix F). During the spawning period releases from the dams have little affect on total flow. About 20 percent of the time in some *dry* water supply conditions, the proposed project operations influence flows in the Russian River in January. Median monthly flows during the spawning period in the Upper Russian River range from 500 to 1400 cfs. Flows at this level are higher than optimal, but continue to provide spawning opportunities in this reach.

Under the Flow Proposal, spawning conditions for *all* water supply conditions at current demand levels are generally ranked low. A large percentage of daily flows are greater than 350 cfs, which receive a score of 2 (Figure 5-23). Excellent-to-optimal conditions would occur 25 to 15 percent of the time, with better habitat conditions predicted for Ukiah. These results are similar to the spawning flows provided by D1610 for the same water supply conditions and demand levels. Spawning conditions under buildout for both water management scenarios were similar to each other and to conditions predicted for current demand levels (Figure 5-24).

Under *dry* water supply conditions, for both current and buildout demand, flow would be lower, providing better spawning conditions under the Flow Proposal and D1610. Good spawning conditions would be present 25 to 40 percent of the time with better conditions found at Ukiah (Figure 5-25). Results are similar for both current and buildout demand levels (Figures 5-25 and 5-26).

Incubation

Flow conditions for incubation are similar under the Flow Proposal and D1610 and as with spawning provide generally unfavorable conditions due to higher-than-optimal flows. Because flows are relatively high during spawning and remain high for most of the incubation period, redd desiccation may occur during the natural recession of flow, but is probably limited to small, localized areas. Redd scour, a more likely effect of flows on redd success, was addressed in Section 5.1.

5.3.8.2 Russian River Temperature

Juvenile Rearing

Juvenile steelhead have a fairly wide tolerance range for water temperatures. Water temperatures from 4 to 20°C provide good-to-optimal habitat conditions (Appendix C). As discussed in Section 5.3.5, under *all* water supply conditions, the Flow Proposal is predicted to produce slightly warmer median monthly water temperatures in the Upper mainstem in June and July and cooler water temperatures in August and October, relative to D1610.

In general, water temperatures are suitable (15 to 20°C) for steelhead rearing in the Upper Russian River (Ukiah, Hopland, and Cloverdale). Water temperatures become less suitable for juvenile rearing with distance below Coyote Valley Dam. Median temperatures at Hopland and Cloverdale are less than 21°C under either demand level, and exceed 20°C in only August and September. These temperatures are considered stressful for steelhead summer rearing, but steelhead can still survive and even flourish if ample food is available. At Healdsburg, median temperatures exceed 22°C from June through September. These temperatures are very stressful, and it is unlikely that growth could be sustained at these temperatures for prolonged periods.

From a comparison of the values in Tables 3-9 and 5-34, median monthly water temperatures in June and July would be slightly higher (less than 1^{o}C) under the Flow Proposal than those provided by D1610 for the same period. The situation is reversed in the August through October period where the Flow Proposal would provide cooler water temperatures than D1610 with differences in median monthly temperatures ranging from 0.4 to 2.1^{o}C.

Under the Flow Proposal the greatest improvement in water temperatures would be evident at Ukiah. The Flow Proposal for *all* water supply conditions would provide excellent-to-optimal thermal conditions 78 percent of the time and poor thermal conditions only 4 percent of the time (Figure 5-27). This represents a gain of 15 percent of days with excellent water temperatures and a reduction of 12 percent of days with poor habitat conditions relative to D1610.

The Flow Proposal under buildout demand levels for *all* water supply conditions would provide similar levels of suitable temperatures as under current demand levels. The differences between the Flow Proposal and D1610 are greater in the late summer period. Water temperatures under D1610 at buildout would be higher, increasing percentage of days when water temperatures are poor (Figure 5-28).

Although under the Flow Proposal for *dry* water supply conditions, the median water temperatures would be slightly higher than those under D1610, they remain in the suitable range for rearing steelhead. The maximum temperature difference between the Flow Proposal and D1610 would be 1.9°C at Ukiah that would occur in September. The difference in water temperatures under the Flow Proposal and D1610 decrease with distance downstream from Coyote Valley Dam toward Hacienda Bridge.

The daily water temperature scores indicate a slightly different perspective than the median monthly temperatures. For *dry* water supply conditions under both current and buildout demand levels, the Flow Proposal would have fewer days at Hopland and Cloverdale where water temperatures were poor (scores of 2 or less) than D1610. At Ukiah, D1610 provides better temperature conditions (Figures 5-29 and 5-30).

Upstream Migration and Spawning

The Flow Proposal would provide suitable water temperatures for upstream migration and spawning throughout the mainstem Russian River. Similar water temperatures are provided by the two water management scenarios regardless of water supply conditions or demand level (Figures 5-27 through 5-30). Most daily temperatures for these lifestages received a score of 4 or greater, with very few days scoring a 2 or less. This is expected, given that flow conditions during these lifestages are largely driven by runoff from unregulated tributary streams.

Incubation

Steelhead embryos incubate in the river gravels from spawning until they emerge as alevins. Steelhead spawn over several months and embryos may be incubating from January through May. Good thermal conditions for steelhead incubation require temperatures of less than 15°C. Temperatures above this cause increasing levels of stress (Appendix C). Water temperatures above 20°C are anticipated to cause substantial mortality.

The Flow Proposal and D1610 would provide similar median temperatures during the incubation period (January through May) under *all* water supply conditions. Most steelhead spawning occurs upstream of Cloverdale. Median monthly water temperatures under *all* water supply conditions range from 8.6 to 14.5°C at Ukiah and from 8.5 to 17°C at Cloverdale. Water temperatures warm with distance downstream from Coyote Valley Dam in March through May, and would reach 17°C at Cloverdale in May and 19°C at Healdsburg.

In *all* water supply conditions, temperatures during the incubation season are generally favorable in the Russian River, with daily water temperatures below 15°C occurring about two-thirds of the time in the downstream locations, and 90 percent of the time in the upstream locations (Figure 5-27). The frequency of stressful temperatures for steelhead incubation increases with distance downstream from Coyote Valley Dam, with poor temperatures (>15°C) occurring about 25 percent of the time from Hopland to Cloverdale. The warm temperatures occur primarily in April and May.

Under the Flow Proposal and D1610, water temperatures during incubation for *all* water supply conditions would be similar regardless of water demand level (Figures 5-27 and 5-28).

In *dry* water supply conditions, temperatures for incubation are slightly less favorable than under *all* water supply conditions. The frequency of stressful scores increases by about 5 to 8 percent from Cloverdale to Ukiah for both the Flow Proposal and D1610.

5.3.8.3 Dry Creek Flow

In Dry Creek, flow conditions are regulated by Warm Springs Dam to a greater degree than the flows on the mainstem Russian River. One of the objectives of the Flow Proposal is to manage Dry Creek to provide better summer rearing conditions while continuing to provide for other life-history activities such as upstream migration and spawning.

Under the Flow Proposal, the median monthly flows during the summer months (June to October) would range from 70 to 55 cfs under *all* water supply conditions, and from about 80 to 65 cfs under *dry* water supply conditions. At buildout, the median flow level would range from 85 to 55 cfs for *all* water supply conditions and from 100 to 60 cfs for *dry* water supply conditions. The magnitude of these flows may be reduced by up to 10 cfs at the downstream end of Dry Creek.

Flows in Dry Creek under the Flow Proposal are predicted to decrease even further relative to D1610 with a reduction in summer flows of 40 to 65 cfs under *all* water supply conditions and 50 to 130 cfs under *dry* water supply conditions.

During *dry* water supply conditions, the D1610 management scenario requires more water to be released from Lake Sonoma to meet demand and to avoid dewatering Lake Mendocino. To maintain suitable salmonid habitat in Dry Creek, the Flow Proposal balances releases from the two reservoirs: decreasing the amount of water released from Lake Sonoma, and increasing releases from Lake Mendocino (hence the higher flows in the Russian River). At buildout, much of the additional water needed to meet demand would come from additional measures, as well as the additional flows in the mainstem, keeping flows at levels to provide good salmonid habitat.

Juvenile Summer Rearing

As discussed in Section 5.3.4, the Flow Proposal would result in reduced flows in Dry Creek relative to D1610 during the summer months. The reduced flows in Dry Creek would provide a substantial benefit to rearing steelhead during the summer months. The *Flow Assessment Study* found that lower flows (around 47 cfs) provided more suitable and optimal habitat for rearing steelhead than did higher flows (90 and 130 cfs). Flows from 14 to 90 cfs provided suitable juvenile rearing habitat conditions in Dry Creek (Appendix C).

For *all* water supply conditions under D1610, flows are near 90 cfs from June through October under current demand, and would be over 90, and up to almost 150 cfs in some months, at buildout. Under the Flow Proposal, these flows would be substantially lower (55 to 85 cfs, and generally less than 75 cfs), increasing the amount of suitable habitat that would be available for juvenile steelhead. As a result, summer rearing scores increase from predominantly 1 and 2 under D1610 to predominantly 4 and 5 under the Flow Proposal for both scenarios (Figure 5-31). Under the Flow Proposal, good-to-optimal habitat conditions would be provided about 90 percent of the time both below Warm Springs Dam and in Lower Dry Creek.

At buildout demand level, the benefits of the Flow Proposal for juvenile steelhead are still evident (Figure 5-32). Excellent-to-optimum habitat conditions would be provided 35 percent of the time at Warm Springs Dam and 55 percent of the time in Lower Dry Creek as compared to less than 1 percent for these two reaches under D1610 at buildout.

In *dry* water supply conditions under current demand, the Flow Proposal would provide habitat conditions similar to those under *all* water supply conditions. Good-to-optimal rearing conditions would be provided 70 and 80 percent of the time below Warm Springs Dam and in Lower Dry Creek, respectively (Figure 5-33). This contrasts with D1610 where excellent-to-optimal rearing conditions are provided only 10 and 20 percent of the time in the same reaches.

At buildout demand levels under *dry* water supply conditions, flows would be increased under both water management scenarios, but to a larger extent under D1610. The flow increases would result in less favorable flow conditions for juvenile steelhead. The Flow Proposal would provide better conditions than D1610. Flows providing good conditions would occur about 65 to 80 percent of the time (Figure 5-34). Under the Flow Proposal the higher flows under *dry* water supply conditions would provide marginal habitat conditions (scores of 1) about 15 percent of the time at Warm Springs Dam and 8 percent of the time in Lower Dry Creek. This is contrasted with marginal habitat conditions that would occur almost 80 percent of the time under D1610 at buildout under *dry* water supply conditions. Under D1610, flows would be greater than 170 cfs from June through September and about 125 cfs in October. This would result in very stressful conditions for juvenile steelhead throughout Dry Creek.

Upstream Migration

Flows of 30 to 325 cfs provide suitable passage conditions for steelhead in Dry Creek. Upstream migration is severely impeded or blocked when flows are less than 10 cfs or greater than 500 cfs (Appendix C).

During the upstream migration period, both water management scenarios provide a similar number of good migration days in Dry Creek. For both current and buildout demand levels, the Flow Proposal and D1610 would provide good migration conditions between 50 and 65 percent of the time, with a higher number of passage days found below Warm Springs Dam (Figures 5-31 and 5-32). The Flow Proposal would provide a higher proportion of days with excellent migration conditions than D1610. This results from an increase in flow under the Flow Proposal relative to D1610 during the adult migration season.

Under *dry* water supply conditions, D1610 would provide slightly better habitat values for upstream migration than the Flow Proposal (Figure 5-33). This occurs because D1610 results in fewer days with flow levels high enough to be considered a barrier to migration (greater than 500 cfs). This would be true for both demand levels (Figure 5-34).

Spawning

Flows in Dry Creek of 30 to 100 cfs provide suitable spawning habitat for steelhead. Spawning conditions are poor at flows higher than 250 cfs and at flows less than 20 cfs (Appendix C).

For *all* water supply conditions under current demand levels, the Flow Proposal and D1610 provide similar conditions for steelhead spawning. Suitable spawning flows would be provided between 50 and 65 percent of the time, with the lower score occurring in Lower Dry Creek for both water management scenarios (Figure 5-31).

For *all* water supply conditions under buildout, D1610 would provide slightly better flows for steelhead spawning than the Flow Proposal. D1610 flows tend to be slightly lower than those under the Flow Proposal and would provide suitable spawning flows about 60 and 40 percent of the time below Warm Springs Dam and in Lower Dry Creek, respectively (Figure 5-32). Under the Flow Proposal, the corresponding conditions would occur about 55 to 36 percent of the time. The frequency of stressful scores would be similar between the two water management scenarios.

For *dry* water supply conditions, the Flow Proposal would provide better overall conditions for spawners, although both water management scenarios would provide very good-to-optimal spawning flows about two-thirds of the time (Figure 5-33). The Flow Proposal is expected to result in good flow conditions about 85 percent of the time near the dam, as compared to about 66 percent of the time under D1610. At the downstream end of Dry Creek, the scores are similar between D1610 and the Flow Proposal. About two-thirds of the flows would provide good conditions and slightly more than half the flows would provide excellent-to-optimal conditions. The results are similar for *dry* water supply conditions under buildout demand level (Figure 5-34).

Incubation

Flows during the steelhead incubation season (January through May) are typically higher for the Flow Proposal than D1610 under *all* water supply conditions by 25 to 75 cfs (Section 5.3.4). Under *dry* water supply conditions, flows are similar between the Flow Proposal and D1610 from January through March, but the Flow Proposal provides higher flows in April and May. The lower flows of D1610 under *all* water supply conditions from January through March, result in better incubation conditions than occur for the Flow Proposal under *all* water supply conditions. At the upstream end of Dry Creek, under D1610, about 55 percent of the time, flows would be between 30 and 150 cfs, providing good flow conditions for incubation. Under the Flow Proposal, good conditions for incubation would be available about 30 percent of the time (Figure 5-31). The Flow Proposal does provide excellent conditions more frequently than D1610, but D1610 would be preferred because of the much greater frequency of good conditions. At the downstream end of Dry Creek, flows would increase due to unregulated local runoff, and conditions for incubation would decline relative to the upstream portion of Dry Creek. Good flow conditions for incubation would be available less than 20 percent of the time under either D1610 or the Flow Proposal. Stressful conditions would occur somewhat more frequently under D1610, but very stressful and potentially lethal flow conditions would occur with about the same frequency under both water management alternatives (Figures 5-31 and 5-32). These results apply to both the current and buildout demand levels.

Under *dry* water supply conditions, flow conditions during the incubation season are similar between the two demand levels in January through March (Figures 5-33 and 5-34). The Flow Proposal results in flows that are about 25 cfs higher than D1610 in April and May. Where flows that are considered stressful occur, they tend to result from flows that are too high. However, for D1610, flows that are too low are more common in April and May. Under *dry* water supply conditions at current demand levels, the flows under

D1610 are lower than optimal. However, these flows still score a 3 approximately 85 percent of the time near the dam. The Flow Proposal's higher flows in April and May shift many of these days from scores of 3 to scores of 5. The same pattern is observed under the buildout demand. In Lower Dry Creek, the two management scenarios result in similar scores. Flows are good for incubation about 40 percent of the time, and would be considered very stressful or potentially lethal about 40 percent of the time. The results for below Warm Springs Dam and Lower Dry Creek apply for both the current and buildout demand levels.

Dry Creek Temperature

Water temperatures in Dry Creek tend to be cool and constant at the upper end below Warm Springs Dam. This is because the release water temperature is carefully managed to meet the needs of DCFH. Water temperatures range from 12 to 13.5°C, which provide excellent-to-optimal conditions for all lifestages. Water temperatures warm somewhat at the downstream end of Dry Creek, but remain within a range that would be considered excellent-to-optimal for most lifestages, most of the time. Water temperatures in Lower Dry Creek are too warm for incubation during the latter part of the season, and rearing temperatures vary between water management and demand scenarios. Water temperature conditions for upstream migration and spawning were similar between the Flow Proposal and D1610 for *all* water supply conditions and demand levels. The following discussion focuses on summer rearing and incubation temperatures.

Summer Rearing

Suitable temperatures for young steelhead range from 4 to 20°C, with optimal temperatures from 12.8 to 15.6°C. Temperatures in this range are always available at Warm Springs Dam. Both the Flow Proposal and D1610 would provide optimal temperatures for young steelhead for *all* water supply conditions and demand levels.

Water temperatures at the lower end of Dry Creek vary with water supply condition and demand level. Because flows are higher, D1610 provides more days with excellent-to-optimal conditions for rearing and suitable temperature conditions occur 100 percent of the time.

For *all* water supply conditions under current demand level, both the Flow Proposal and D1610 would provide nearly the same number of days when water temperatures are suitable (scores 3 or greater) for summer rearing (Figure 5-35). Under the Flow Proposal, the water temperatures in Lower Dry Creek would be in the suitable range 98 percent of the time. At buildout demand levels, water temperatures in Lower Dry Creek would improve under both scenarios. Once again, both scenarios provide suitable rearing conditions nearly 100 percent of the time, with D1610 providing a greater number of days with optimal conditions (Figure 5-36). During *dry* water supply conditions under both current and buildout demand levels (Figures 5-37 and 5-38), water temperatures would be similar to those discussed for *all* water supply conditions with buildout demand level. Both water management scenarios provide suitable water temperatures in Dry

Creek for summer rearing. The lower flows under the Flow Proposal result in slightly lower temperature scores in the lower reach.

Incubation

For incubation below Warm Springs Dam, temperatures would be excellent to optimal about 80 percent of the time. The remaining days would provide good temperatures for incubation. The days with scores of 3 result from temperatures that are too warm, which occur primarily in May. These results apply to both demand scenarios under *all* water supply conditions (Figures 5-35 and 5-36). Under *dry* water supply conditions, temperature scores would again be excellent to optimal near the dam, but the frequency with which temperatures would be only good for incubation would increase to about 33 percent of the time (Figures 5-37 and 5-38). For incubation, water temperatures at the lower end of Dry Creek are good to optimal about 70 percent of the time, but can be very stressful about 10 to 15 percent of the time. These stressful temperatures can occur during April and May, when water temperatures exceed 15°C.

5.3.8.4 Summary

Implementation of the Flow Proposal would benefit steelhead in both the Russian River and Dry Creek. Summer rearing habitat improvements would reap the greatest benefit. Summer rearing conditions would be close to optimal in Upper Russian River more than 64 to 70 percent of the time, compared to only 35 to 40 percent of the time under D1610. Young steelhead would also benefit from the lower water temperatures (0.4 to 2.1°C lower than D1610) in the Upper Russian River in August through October. These benefits in summer rearing conditions would help relieve the summer rearing bottleneck that is currently thought to limit steelhead production in the Russian River watershed and would promote the recovery of this species. The lifestages in the mainstem river during the winter and spring (upstream migration, spawning, and incubation) would experience similar habitat conditions under either water management scenario.

Summer rearing habitat for young steelhead in Dry Creek would improve substantially under the Flow Proposal. Rearing conditions would be excellent to optimal 50 to 75 percent of the time, and good 90 percent of the time. This represents a substantial improvement over the predominantly poor conditions found under D1610 (good conditions occur only 35 percent of the time). The contrast is especially marked for the buildout demand level. Other habitat improvements for spawning and upstream migrations would occur under some water supply and demand conditions. However, incubation would experience less favorable conditions under the Flow Proposal than D1610 because of higher winter flows. During this time of year, flows are largely due to natural runoff from unregulated tributaries and project operations have only a minor influence on flows.

5.3.9 CHINOOK SALMON

Chinook salmon use the Upper and Middle Russian River as well as large tributaries such as Dry Creek for spawning and rearing habitat. They use the Lower Russian River and the Estuary predominantly as a migration route between the ocean and upstream habitats. The Estuary may also be used for rearing. The Flow Proposal could affect migration, spawning, and rearing in the mainstem Russian River and in Dry Creek. Chinook salmon use the Russian River watershed in the winter and spring when flows are high due to rainfall and runoff from unregulated tributaries. The Flow Proposal has less influence on flow and habitat during this period, particularly in the Russian River. Chinook are generally absent from the system from July through late September or October, when project operations have their largest effect on flows.

Because Chinook salmon are in the watershed during the wetter part of the year, the flows they experience are usually higher than optimal for most species and lifestages. Many of the lifestages, and particularly young fry and juveniles are likely using areas that provide velocity refuge. The success of Chinook salmon may be influenced by the availability of such refuge areas. This is particularly true of Dry Creek, because of its more incised nature and lack of connection with its flood plain.

5.3.9.1 Russian River Flow

Juvenile Rearing

Suitable rearing conditions for juvenile Chinook salmon in the Upper and Middle Russian River are provided by flows ranging from 50 to 275 cfs (based on criteria provided in Appendix C). Flows in the Upper Russian River often exceed these levels during the Chinook rearing period (February through May). These winter and spring flows are largely controlled by runoff from unregulated tributaries and are typically not the result of project operations.

The flows that would occur during the Chinook salmon rearing period under the Flow Proposal are similar to those provided by D1610. As an example, at Cloverdale under *all* water supply conditions, median flows during the February-June rearing period range from 1400 cfs to 180 cfs, respectively (See Section 5.3.5 and Tables 3-8 and 4-5).

In general, under both the Flow Proposal and D1610, flows during the rearing season would be frequently higher than optimal for rearing Chinook salmon. Flows greater than 275 cfs would occur 70 to 80 percent of the time (Tables 3-8 and 4-5). Figure 5-39 presents the evaluation of rearing habitat for Chinook salmon under *all* water supply conditions and current demand levels. The high flows that occur much of the time contribute to marginal habitat conditions in this reach for rearing Chinook salmon. Poor habitat conditions (scores of 2 or less) occurred at Ukiah, Hopland, and Cloverdale 70 to 75 percent of the time. Under these conditions Chinook salmon fry are likely restricted to areas of lower velocity along channel margins and in pools, or may emigrate shortly after emergence. Habitat conditions improve during the latter half of the rearing period when flows are lower. Similar conditions would occur for rearing Chinook salmon under buildout demand levels for both the Flow Proposal and D1610 under *all* water supply conditions (Figure 5-40).

Because flows are lower under *dry* water supply conditions, there is an improvement in rearing conditions compared to *all* water supply conditions. For *dry* water supply conditions, both management scenarios provide good-to-optimal rearing habitat 38 to 45 percent of the time at Ukiah, Hopland, and Cloverdale, while stressful flows (scores ≤ 1) occur only 15 to 32 percent of the time (Figures 5-41 and 5-42, respectively). The overall improvement in habitat conditions is due to a reduction in flow rates between February and April. The Flow Proposal and D1610 provide similar conditions for juvenile rearing under current and buildout demand levels under *dry* water supply conditions.

Upstream Migration

Under current operations (D1610), the Estuary is managed as an open system to prevent local flooding near Jenner. This open system is necessary because of the high flow rates in the lower river during most of the summer. Because of the open system, a few Chinook salmon have entered the Russian River as early as August, although the peak of upstream migration has generally been in October or November (Section 2.2.4).

Under the Flow Proposal, the Estuary would be managed as a closed system. The sandbar at the mouth of the Estuary would remain closed until the rainy season starts, when flows in the river naturally increase, or when the USACE is required to begin releasing additional water out of Lake Mendocino (normally in mid-October), to bring them down to flood control elevation. The habitat conditions for upstream migration presented in this section are for the period from August 15 to January 15 for D1610, based on the current D1610 management scenario with the bar open. The Flow Proposal habitat conditions are evaluated based on a migration season from October 15 to January 15, reflecting the proposed management of the Estuary as a closed system.

Flows that provide good upstream passage conditions for adult Chinook salmon in the mainstem Russian River range from 100 to 2,000 cfs. These flows represent scores of 3 or higher according to the evaluation criteria (Appendix C).

The Flow Proposal and D1610 management scenarios provide similar conditions for upstream migration under *all* water supply conditions. Daily flows are good to optimal for passage about 77 percent of the time near Healdsburg and 87 percent of the time in the Upper Russian River (Ukiah). Flow conditions are expected to be poor for migration about 7 to 10 percent of the time (Figure 5-39). Under buildout demand levels, conditions for upstream migration are also similar for the Flow Proposal and D1610, with about 80 and 87 percent of flows receiving scores of 3 or greater at Healdsburg and Ukiah, respectively (Figure 5-40).

In *dry* water supply conditions, the Flow Proposal provides better upstream migration scores downstream of Cloverdale, because the sandbar at the mouth of the estuary is closed during August and September, when low flows predominate. Under current water demand levels, flows at Healdsburg are good to optimal (scores ≥ 3) about 60 percent of the time for the Flow Proposal compared to 40 percent of the time for D1610. In the Upper Russian River, however, D1610 management is predicted to provide a higher frequency of good migration flows (65 percent vs. 50 percent) (Figure 5-41). Poor flow conditions (scores ≤ 1) occur at about the same frequency for both management scenarios throughout the Russian River. Under buildout demand levels, the Flow Proposal is expected to provide better flows for upstream migration in the lower mainstem relative to D1610, with good-to-optimal flows occurring almost twice as often at Healdsburg. In the upper mainstem, migration conditions are similar under both management scenarios (Figure 5-42).

Spawning

Chinook salmon spawn in the Upper and Middle Reaches of the Russian River from November through January. Suitable spawning conditions are provided at flows ranging from 130 to 400 cfs (scores ≥ 3, Appendix C). Flows in the Russian River often exceed these levels during the Chinook salmon spawning period because flows are controlled mostly by rainfall runoff and not project operations.

The expected median flows are similar under the Flow Proposal and D1610 for both *all* and *dry* water supply conditions under current and buildout demand levels. The current median flows at Ukiah generally increase from November through January, ranging from 170 cfs to greater than 740 cfs, respectively. Flow increases from tributary inflow occur with distance downstream. Corresponding flows in Cloverdale are 190 to 1,080 cfs for the November-January time frame (Table 3-8). Flows under the Flow Proposal are quite similar (Table 4-5), differing by less than 5 percent. Flows from 150 to 300 cfs provide excellent-to-optimal spawning conditions (scores of 4 or 5). Flows are frequently higher than this in the latter portion of the spawning period.

Under *all* water supply conditions with current demand, spawning flows under D1610 are similar to those under the Flow Proposal. Both management scenarios provide good-to-optimal spawning conditions (scores ≥ 3) about 38 percent of the time. Stressful habitat conditions, with daily flow conditions receiving a habitat score of 1 or less, occur between 38 to 45 percent of the time (Figure 5-39). Stressful conditions are generally due to flows being too high (> 400 cfs). As previously discussed, these higher flows are due to natural rainfall and runoff from unregulated tributaries and are not due to project operations. However, a small portion of low scores is due to low flow conditions (less than 100 cfs). Both management scenarios provide similar conditions under current and buildout demand levels (Figures 5-39 and 5-40).

For *dry* water supply conditions under current demand levels, the Flow Proposal and D1610 would provide similar conditions for Chinook spawning (Figure 5-41). *Dry* water supply conditions would provide slightly worse spawning conditions than *all* water supply conditions, with good-to-optimal flows occurring about 24 percent of the time, under both demand levels (Figures 5-41 and 5-42). Poor flows (scores of 1 or less) occurred about 50 to 55 percent of the time, generally because of lower than optimal flows.

Incubation

Median flows during the Chinook salmon incubation period under *all* water conditions are predicted to be similar for the Flow Proposal and D1610 under current and buildout demand levels and for both water supply conditions. Under *all* water conditions, flows during the incubation season are good to optimal (scores of 3 to 5, flows between 130 and 400 cfs) between 33 to 42 percent of the time above Healdsburg and 25 percent of the time at Healdsburg. Marginal-to-poor flow conditions occur about 62 percent of the time (Figures 5-39 and 5-40). In general, flows during the incubation season in the Russian River are high enough (> 400 cfs) to impair incubation, through the potential scouring of redds, especially in the lower mainstem.

Under *dry* water conditions, the Flow Proposal and D1610 again provide similar incubation conditions for current and buildout demand levels (Figures 5-41 and 5-42). About 55 percent of daily flows were good to optimal (score ≥ 3) for incubation in the Upper Russian River (Ukiah). Flow conditions for incubation get somewhat worse downstream from Ukiah, with good-to-optimal flows occurring about 38 percent of the time near Healdsburg. Stressful spawning conditions are due to both high and low flow conditions. Flows that are too low tend to occur more frequently early in the season, while flows that are too high occur more frequently near the end of the incubation season.

5.3.9.2 Russian River Temperature

Juvenile Rearing

Water temperatures are generally very favorable for rearing in the Upper Russian River. Excellent-to-optimal water temperatures for juvenile Chinook salmon rearing range from 8 to 18^{o}C. The Flow Proposal would provide these temperatures in the Upper Russian River between 60 and 95 percent of the time for both current and buildout demand levels (Figures 5-43 and 5-44). The best temperatures would occur at Ukiah. Water temperatures would warm somewhat moving downstream from Coyote Valley Dam. Water temperatures would remain quite good at Cloverdale, with suitable water temperatures (scores of 3 or higher) occurring 90 percent of the time. Poor temperature conditions (scores of 2 or less) would occur only about 10 percent of the time. At Healdsburg, the frequency of poor temperature conditions would increase, and poor conditions would occur about 25 percent of the time, with some potentially lethal conditions (scores less than 1) occurring toward the end of the rearing period. However, even at Hacienda, the furthest downstream station, good-to-optimal temperature conditions would occur about 75 percent of the time.

The Flow Proposal and D1610 would provide similar temperature conditions for both *all* and *dry* water supply conditions and for both current and buildout demand levels (Figures 5-45 and 5-46).

Upstream Migration

Temperatures suitable for upstream migrants range from 5.2^{o}C to 18.4^{o}C for Chinook salmon (Appendix C). The Flow Proposal provides much more suitable temperature conditions than under D1610, with good-to-optimal temperatures being a larger proportion of the available migration period due to the closure of the sandbar at the mouth of the Estuary. This prevents Chinook salmon adults from entering the Russian River when temperatures are too warm. Under *all* water supply conditions, the Flow Proposal would provide temperatures within a suitable range for migration (scores ≥ 3) about 90 percent of the time in the Upper Russian River and 97 percent of the time from the mouth of Dry Creek to the Estuary (Figures 5-43 and 5-44).

For upstream migration, the Flow Proposal provides substantially better temperature scores. This is because Chinook salmon cannot enter the river in August and September when water temperatures are very warm. The frequency of stressful and very stressful temperatures drops from over 40 percent of the time under D1610 to between 2 and 11 percent of the time under the Flow Proposal in the Lower and Upper Russian River, respectively. Under *dry* water supply conditions, the Flow Proposal continues to provide excellent temperature conditions (Figures 5-45 and 5-46).

Spawning

As described in Appendix C, water temperatures suitable for spawning Chinook salmon range from 3.5^{o}C to 15.2^{o}C. Water temperatures for spawning under the Flow Proposal would be similar to those provided by D1610, with flows providing excellent-to-optimal temperature conditions 81 to 90 percent of the time in the Upper and Lower mainstem, respectively. This pattern is consistent under *all* and *dry* water conditions, and for current and future buildout demand levels (Figures 5-43 through 5-46).

Incubation

The temperature range that provides suitable incubation conditions for Chinook salmon incubation is 3^{o}C and 15^{o}C (Appendix C). Water temperatures for incubation under the Flow Proposal would be similar to those provided by D1610, with both scenarios providing excellent-to-optimal temperature conditions about 87 percent of the time. This pattern is consistent under *all* and *dry* water conditions, and for current and full buildout conditions (Figures 5-43 through 5-46).

5.3.9.3 Dry Creek Flow

Juvenile Rearing

Suitable conditions for Chinook salmon rearing in Dry Creek occur at flows ranging from 25 cfs to 110 cfs (Appendix C). Flows often exceed this range in Dry Creek in the spring.

Median rearing flows for Chinook salmon are lower under the Flow Proposal than for D1610 in May and June, but higher in February and March. Under the Flow Proposal, flows between February and June range from 63 to 350 cfs below Warm Spring Dam and

57 to 562 cfs in Lower Dry Creek under *all* water conditions. Corresponding median flows for D1610 range from 95 to 278 cfs below Warm Springs Dam and 87 to 482 cfs in Lower Dry Creek. At buildout demand levels, flows under D1610 would generally be lower in February and March (45 to 120 cfs lower) and about the same in April through June. Flows under the Flow Proposal at buildout demand levels would remain similar to those under the Flow Proposal at current demand levels.

Under *dry* water conditions, median rearing flows would be similar for the Flow Proposal and D1610 at about 75 cfs during January through March. In April and May, D1610 flows would drop to 25 cfs, while the Flow Proposal flows would be about 51 cfs. These flows would be similar for each scenario under current and buildout demand levels.

The Flow Proposal is predicted to provide slightly better rearing conditions for Chinook salmon in Dry Creek relative to D1610, under *all* water supply conditions (Figure 5-47). Daily flows under the Flow Proposal at current demand levels would provide excellent-to-optimal rearing conditions (scores ≥ 4) about 60 percent of the time in Upper Dry Creek and about 43 percent of the time in Lower Dry Creek. D1610 provides corresponding conditions about 6 percent less frequently, although both management scenarios provide a similar frequency of good-to-optimal conditions for rearing. These trends are similar at buildout demand levels (Figure 5-48).

Chinook salmon rearing conditions under *dry* water conditions improve dramatically under the Flow Proposal compared to D1610. Under current and buildout demand levels, daily flows for the Flow Proposal receive scores of 4 or greater about 85 percent of the time below Warm Spring Dam and 55 percent of the time in Lower Dry Creek. These values are approximately twice the frequency with which they occur under D1610 (Figures 5-49 and 5-50).

Upstream Migration

Flows suitable for passage of upstream migrating Chinook salmon in Dry Creek range from 45 to 325 cfs. These flows represent scores of 3 or higher according to the evaluation criteria (Appendix C). The Flow Proposal and D1610 are predicted to provide similar conditions for upstream migration. Under *all* water supply conditions with current demand, adult Chinook salmon are predicted to experience good-to-optimal conditions about 90 to 95 percent of the time in Upper Dry Creek, and 85 percent of the time in Lower Dry Creek (Figure 5-47). The frequency of poor upstream flows (scores of 1) is similar between the Flow Proposal and D1610. Poor conditions are due primarily to lower flows during October. Both management scenarios provide similar conditions for upstream migration under current and buildout demand levels (Figure 5-48).

Under *dry* water supply conditions, D1610 provides slightly better upstream migration conditions than the Flow Proposal for current and buildout demand levels (Figures 5-49 and 5-50). Both management scenarios provide good to optimal flows a large proportion of the time in both Upper and Lower Dry Creek. The slight decrease in Flow Proposal scores relative to D1610 is primarily due to lower flows during October. This flow reduction is intended to improve rearing habitat for juvenile salmonids in Dry Creek (especially coho salmon and steelhead).

Spawning

Chinook salmon spawn throughout Dry Creek. Flows that provide suitable spawning conditions in Dry Creek for Chinook range from 40 to 150 cfs (Appendix C). Flows often exceed these levels during the Chinook spawning period.

Under *all* water supply conditions for current and buildout demand levels, optimal flows (i.e., score = 5) are much more frequent under the Flow Proposal than D1610 (Figures 5-47 and 5-48), although the frequency of scores of 4 or higher is similar between the two scenarios. Daily flows below Warm Springs Dam are predicted to provide very good conditions for spawning, with flows receiving a score of 4 or 5 about 85 percent of the time under both scenarios. In Lower Dry Creek, flows are excellent to optimal for spawning under the Flow Proposal about 58 percent of the time compared to about 55 percent of the time under D1610. Good spawning conditions occur about 63 percent of the time in Lower Dry Creek for both the Flow Proposal and D1610.

Under *dry* water conditions, the predicted frequency of daily flows that receive spawning scores of 4 or greater increases over *all* water supply conditions for both management scenarios (Figures 5-49 and 5-50). In general, flows are good to optimal for spawning 90 to 95 percent of the time throughout Dry Creek. The buildout demand level has little effect on the frequency of daily flows that provide suitable conditions for spawning.

Incubation

The Flow Proposal would provide similar conditions to D1610 for incubation of Chinook salmon embryos under *all* water supply conditions for the current demand level. Both management scenarios provide excellent-to-optimal incubation flows about 70 percent of the time in Upper Dry Creek and 38 percent of the time in Lower Dry Creek. The Flow Proposal, however, yields a much higher frequency of optimal flows (i.e., score = 5) throughout Dry Creek relative to D1610. This pattern is consistent under both current and buildout demand levels. Scores less than 4 are due to higher-than-optimal flows for incubation.

Under *dry* water supply conditions, there is no difference in incubation conditions between the Flow Proposal and D1610. Both management scenarios are predicted to produce better conditions for incubation in *dry* water supply conditions than in *all* water supply conditions, due to a decrease in flow rates. The frequency of excellent-to-optimal flows is again greater in Upper Dry Creek (88 percent) than in the Lower reaches (57 percent) near the confluence with the Russian River. Under buildout demand levels the frequency of flows providing suitable conditions for incubation would be similar.

5.3.9.4 Dry Creek Temperature

Juvenile Rearing

Temperatures are generally highly suitable for Chinook salmon rearing throughout Dry Creek under both the Flow Proposal and D1610 under current conditions (Figure 5-51). In Upper Dry Creek, both management scenarios have excellent temperatures (8 to 17°C) all of the time. In Lower Dry Creek, some warmer temperatures (up to 20°C) are expected under both scenarios, with D1610 resulting in a slightly lower frequency of these warmer temperatures. At buildout, temperature scores improve slightly in Lower Dry Creek for D1610 (Figure 5-52). About 5 percent more days receive a score of 4. Scores remain the same under the Flow Proposal.

Temperature conditions are similar for both *all* and *dry* water supply conditions (Figures 5-53 and 5-54).

Upstream Migration

Under *all* and *dry* water supply conditions, both the Flow Proposal and D1610 provide excellent temperature conditions for upstream migrant Chinook salmon. Scores of 4 or higher are present 84 percent of the time or more, and scores of 3 or higher are present 100 percent of the time. The Flow Proposal provides slightly better conditions in Lower Dry Creek than D1610 under current demand levels. However, at buildout demand, both management scenarios are predicted to provide excellent-to-optimal temperatures throughout Dry Creek almost all the time (Figures 5-51 through 5-54).

Spawning

Both the Flow Proposal and D1610 provide excellent temperature conditions for Chinook salmon spawning under *all* and *dry* water supply conditions. Temperatures are expected to be optimal almost 100 percent of the time throughout Dry Creek for both current and buildout demand levels.

Incubation

Both the Flow Proposal and D1610 also provide excellent temperature conditions for Chinook salmon incubation under *all* and *dry* water supply conditions. Temperatures are expected to be excellent to optimal at least 95 percent of the time throughout Dry Creek for both current and buildout demand levels.

5.3.9.5 Summary

In the Russian River, the Flow Proposal would primarily improve conditions for upstream migration relative to D1610. Under current D1610 operations, the Estuary is managed as an open system to prevent local flooding, which allows Chinook salmon to enter the Russian River as early as August when flow and temperature conditions are not suitable for migrating adults. Under the Flow Proposal, the Estuary would be managed as a closed system, preventing Chinook salmon from entering the Russian River until the sandbar is breached either by rain driven flows or artificially in mid-October, when the USACE begins drawing Lake Mendocino down to flood control levels. The Flow Proposal and D1610 result in similar flow scores for upstream migration during *all* water conditions, in spite of the bar closure. Under *dry* water supply conditions, the Flow Proposal provides a higher frequency of suitable flows for upstream migration. This is especially true for *dry* water supply conditions under buildout demand levels, where the Flow Proposal is predicted to provide good-to-optimal flows almost twice as often as D1610 in the lower and middle Russian River.

Water temperature conditions for adult migration are predicted to improve under the Flow Proposal. By managing the Estuary as a closed system, migrating adults are not exposed to higher water temperatures associated with low flows in August and September. In general, the frequency of stressful and very stressful temperatures declines from over 40 percent under D1610 to about 7 percent under the Flow Proposal.

Both water management scenarios are expected to provide similar conditions for spawning, incubation and rearing. Since fry and juveniles Chinook salmon occupy the Russian River from February through June, flows tend to be higher than optimal for rearing. Conditions are somewhat better for spawning and incubation under the Flow Proposal than D1610 with suitable flows occurring around 40 percent of the time for *all* water supply conditions and 25 to 35 percent of the time for *dry* water supply conditions. Both management scenarios are predicted to provide suitable temperatures for spawning, incubation, and rearing. In general, excellent-to-optimal temperature conditions are expected to occur between 80 to 90 percent of the time during these life history stages.

In Dry Creek, the Flow Proposal would improve rearing conditions for Chinook salmon, especially near Warm Spring Dam under *dry* water conditions. Both management scenarios are expected to provide similar habitat conditions for upstream migration, spawning and rearing, with a high frequency of good to optimal flow conditions. Water temperatures are similar for the Flow Proposal and D1610 for all life history stages and are highly suitable for Chinook salmon throughout Dry Creek.

5.3.10 Estuary Management

The objectives of the proposed Estuary management are to improve habitat for listed fish species and to prevent flooding of local property.

Summertime breaching of sandbars has been found to negatively affect habitat conditions in lagoons (Smith 1990). The Flow Proposal would reduce inflow to the Estuary, which would allow the elimination of artificial breaching of the sandbar during the summer months. Artificial breaching under the Storm-Flow Management proposal may be required to manage storm flow in the spring or fall, and in some dry winters, to prevent flooding of adjacent property.

5.3.10.1 Issues of Concern

In the Russian River, the current Estuary management program implements a program of summertime artificial breaching. The sandbar is breached several times in the summer/early fall, which creates fluctuating DO, temperature, and salinity conditions in the Estuary. Fluctuating salinity and low DO conditions decrease invertebrate populations upon which juvenile salmonids feed (ENTRIX 2002b). Elimination of summertime artificial breaching would improve lagoon habitat conditions for salmonids over baseline conditions by eliminating fluctuating conditions and stabilizing suitable water quality. Coastal lagoon processes that affect salmonid habitat are described in greater detail in the following section.

In addition, the current management plan results in the sandbar being open in the early portion of the migration period for Chinook salmon (late August and September). Thus, adult Chinook salmon can enter the river system before river conditions are suitable for upstream migration. The proposed project seeks to address these issues.

CDFG has expressed concern about the effects of artificial breaching on the Russian River lagoon, which functions as a nursery area for juvenile fish and wetland habitat, primarily in the lower portion of Willow Creek (CDFG 2002). In the *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002), CDFG recommends the evaluation of a no-breach alternative as well as lagoon sampling to study conditions for salmonid utilization.

5.3.10.2 Coastal Lagoon Processes during the Low-Flow Season

Estuaries and lagoons provide important rearing habitat for salmonids (Smith 1990; Larson 1987; Anderson 1995, 1998, 1999; Cannata 1998; Reimers 1973; Healy 1982; Levy and Northcote 1982; Kjelson et al. 1982; Simenstad et al. 1982; Anderson and Brown 1982; Meyers and Horton 1982). Steelhead rearing has been documented in many lagoons in Central and Northern California (Smith 1990; Larson 1987; Anderson 1995, 1998, 1999; Cannata 1998). Chinook salmon and coho salmon have also been found rearing in coastal lagoons to the north of the Russian River (Anderson and Brown 1982; Cannata 1998), although it is not clear if coho salmon have extended rearing periods in these lagoons (Anderson and Brown 1982). Steelhead have been caught in the Estuary in the summer during the 5-year monitoring study (MSC 2000).

In California estuaries, inflow is high during the rainy season, then decreases during the dry season. During the summer, a sandbar forms across the river mouth, impounds water, and forms a lagoon. Initially, a saltwater layer is trapped on the lagoon bottom under a freshwater layer. Through natural processes, this saltwater layer becomes warm, water quality initially declines, DO becomes depleted, and anoxic conditions form (Smith 1990; MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Research conducted in other coastal lagoons indicates that seepage of the saltwater layer through the sandbar, combined with adequate inflow of fresh water from the river, results in a “freshening” of the lagoon, which results in excellent rearing habitat for salmonids. Maintaining stable conditions also benefits the invertebrate foodbase (Smith 1990).

The rate of conversion to a freshwater system depends on the amount of salt water impounded when the sandbar forms. It also depends on the amount of inflow to the system, which contributes to both dilution and to higher water levels that can increase the rate of seepage through the sandbar. High inflows in the spring allow relatively rapid conversion of an impounded lagoon to fresh water. If the sandbar is breached, salt water flows into the lagoon. When the sandbar reforms, salinity stratification occurs, and the cycle of freshening must begin anew. If a sandbar is breached when summer flows are very low, the rate of conversion to a freshwater system can be very slow, resulting in long transition periods, which may not even occur in the remainder of the season (Smith 1990). Therefore, sandbar breaching during the mid to late summer, when inflow is low, is of particular concern.

This process was intensively studied in smaller Central California coast lagoons in Pescadero, San Gregorio, Waddell, and Pomponio creeks. Although these lagoons are small, similar physical processes likely occur in other California lagoons, such as the Russian River Estuary. Smith (1990) found that with the conversion of the system to fresh water, water temperature decreases, DO levels increase, and excellent rearing conditions develop. Despite the shallowness and warm summer water temperatures in these small coastal lagoons, these lagoons are heavily used by steelhead for rearing. Under the Flow Proposal, there would be sufficient inflow to the Estuary to freshen the lagoon once the sandbar closes, and through the physical processes documented in the Smith (1990) studies, suitable habitat for salmonids and their foodbase are likely to develop. Furthermore, shallow water habitat in the lower portion of Willow Creek Marsh may also benefit from stable conditions and provide food resources for salmonids.

Summertime breaching of sandbars, especially during low-flow summer months, has been found to severely alter habitat conditions in lagoons, including water quality and food availability, because salinity stratification results in higher water temperatures and low DO levels, which negatively affect steelhead and their invertebrate foodbase (Smith 1990). Smith (1990) documented poor steelhead growth during periods of warm, stratified water conditions, particularly during long transition periods to freshwater conditions (Smith 1990). In the Navarro River, up to about 5 miles of the river is inundated by a lagoon when a sandbar forms. Many steelhead rear in this estuarine system year-round, particularly Age 1+ and 2+ fish (based on fish-scale analyses for age and early life-history patterns) (Cannata 1998). Closure of the sandbar in the late summer/early fall during the course of a two-year study appeared to result in an upstream movement of steelhead and a temporary reduction in growth rate, but this was followed by an increase in growth rate a short while later with inflow of fresh water from the river (S. Cannata, CDFG, pers. comm. 2000). Steelhead avoided high lagoon water temperatures and low DO levels by residing in the upper water column or moving upstream until the lagoon freshened (Cannata 1998).

Smith (1990) documented that invertebrate populations crashed each time the lagoons went through the transition to fresh water. When the estuaries were open to tidal exchange, saltwater species like crabs and shrimp (*Neomysis* sp.) were abundant. When sandbar formation resulted in anoxic conditions at the substrate in the deeper waters, amphipods were eliminated from those areas. Euryhaline amphipods (*E. O. Gammarus* spp. and *Corophium* spp.) were present throughout the year and their abundance did not appear to depend on salinity conditions. Freshwater insects, especially diving beetles (*Dytisidae*), water boatmen (*Corixidae*), and midge larvae (*Chironomidae*) became abundant in the pondweed after the lagoons converted to fresh water. Continuous breaching, such as occurred at San Gregorio lagoon in the summer of 1986, resulted in low overall invertebrate populations. As salinity stratification was eliminated by freshwater inflow and wind, DO was restored and invertebrate populations recovered (Smith 1990).

Steelhead that rear in food-rich, freshwater lagoons may experience higher growth rates than steelhead that rear in the stream. Smith (1990) analyzed scale samples from adult steelhead and showed that these fish generally comprised a substantial portion of the adult returns (at least 70 percent of a limited sample in Pescadero Creek from 1985 to 1989). McKeon (1985) determined that Estuary-reared juvenile Chinook salmon in Redwood Creek grew to a larger size than river-reared fish, which is likely to improve their chances for ocean survival and return.

The lagoon in Redwood Creek in Humboldt County provides important steelhead and Chinook salmon rearing habitat. This small estuarine system has been significantly modified by flood control levee construction, which has eliminated or degraded much of the estuary as viable rearing habitat (Anderson 1995, Larson 1987). Nevertheless, Anderson and Brown (1982) found that juvenile Chinook salmon do not spend a majority of rearing time in tributary or mainstem habitat in this watershed, confirming the importance of the estuary for rearing. Larson (1987) documented an uncontrolled breach by local landowners in July 1980 that exposed rearing fish to an abrupt transition from fresh to salt water, flushed juveniles to the ocean, eliminated most of the rearing habitat in the lagoon, and probably reduced ocean survival of these fish. Controlled breaching is currently conducted to keep water levels in the Redwood Creek lagoon higher than they would be with uncontrolled breaching, which helps maintain as much rearing habitat in the lagoon as possible (NMFS 1998c; Anderson 1998, 1999).

In summary, coastal lagoons provide important rearing habitat for juvenile salmonids. Summertime artificial breaching of sandbars severely alters habitat conditions in lagoons. If an estuary remains open, good water quality can be maintained with tidal mixing or high river flows. In a lagoon (sandbar-closed), good water quality develops when the system is converted to fresh water, and stable habitat conditions form. Infrequent breaching, especially during low-flow summer months, impairs water quality because salinity stratification repeatedly results in periods of higher water temperatures and low DO levels. Fluctuations in temperature, DO and salinity affect salmonid habitat, primary production, and the abundance of aquatic invertebrates upon which young salmonids feed. The frequency of breaching and the amount of freshwater inflow are two major factors that influence water quality in a lagoon or estuary system.

Given the importance of other estuarine systems for juvenile salmonid rearing and the limited amount of juvenile rearing habitat in the Lower Russian River mainstem (see Section 2.1.5), the proposed project represents an important opportunity to improve summer rearing habitat in the watershed in a highly productive estuarine environment. The upper portion of the Estuary may be important for juvenile rearing, especially since a coastal fog belt moderates high river water temperature in the summer. Chinook salmon that migrate down the Russian River in the spring may rear for some time in the food-rich

Estuary. The tributaries in the lower Russian River contain high quality steelhead spawning and rearing habitat, and therefore steelhead have easy access to estuarine rearing habitat. Under the proposed Low-Flow Estuary Management program, the lagoon would provide good summer water quality and an increased food supply, which would result in good growth rates for listed fish species and increased chances for their ocean survival. Summer rearing habitat may be a limiting factor for salmonids in the Russian River watershed and therefore the proposed Estuary management provides an important opportunity provide additional, high-quality, oversummering habitat.

5.3.10.3 Potential Effects of Artificial Breaching

The Low-Flow and Storm-Flow Management proposals have the potential to affect salmonid rearing habitat and migration. When the sandbar forms, water quality degrades in the short-term. However, by eliminating summertime artificial breaching, fluctuating conditions would be eliminated, and long-term (throughout the summer) improvements to water quality in the Estuary would be realized. This can directly affect salmonid habitat, primary productivity, and the availability of aquatic invertebrates upon which young salmonids feed. Artificial breaching can, in combination with flow dilution, reduce the concentration of nutrients and toxic runoff from the watershed by opening the Estuary to tidal flushing. With elimination of summer breaching, water-quality conditions in the lagoon would change.

The proposed Estuary management would also affect fish passage during both downstream and upstream migrations. Adult Chinook salmon congregate at the mouth of the river as early as late-August, and if artificial breaching is no longer conducted during this time, early migrants would be prevented from entering the river prematurely. Under the Storm-Flow Management program, the sandbar would be breached close to the time it would naturally breach, and migrants would remain in the ocean until rising river flow improves river conditions. Sandbar breaching activities have the potential to flush juvenile salmonids out of the lower Estuary before they are ready. Finally, artificial breaching of the sandbar has the potential to increase the risk of predation on listed fish species by concentrating fish or increasing incidental bycatch from angling. The issues evaluated are summarized as follows:

- Effects on water quality
- Effects on juvenile rearing habitat
- Opportunity for premature adult upstream migration
- Effects on juvenile downstream migration
- Changes in risk of predation
- Changes in incidental angling pressure or poaching

Potential effects are evaluated for the sandbar-closed management scenario under the Low-Flow Estuary Management proposal. Effects of artificial breaching for Storm-Flow Management are also assessed.

5.3.10.4 Low-Flow Estuary Management/Sandbar-Closed

Water Quality

The Russian River flow would be managed so that once the sandbar closed, freshwater inflow would be sufficient to freshen the lagoon. Flow would be reduced over the summer, following the natural flow in Austin or Maacama creeks, but it would not be reduced below a minimum floor of 35 cfs at the Hacienda gage. The lagoon water surface elevation, measured at the Jenner gage, would be approximately 7 feet when the sandbar first closes, but could be expected to vary from 8 feet in the early summer to approximately 6.0 feet later in the summer.

The preliminary estimate of flow at which the sandbar is predicted to close is 90 cfs at Hacienda, although sandbar closure would vary depending on ocean conditions near the river mouth. Modeled median flows at Hacienda are listed in Table 5-35. Based on the 90 cfs estimate, the sandbar would be predicted to close in June or July, although in *critically dry* years it may close earlier. Except in *critically dry* years, modeled median flow during the summer months ranges from 52 to 78 cfs. In *critically dry* years, flow may drop to the minimum floor of 35 cfs. These flows would provide sufficient inflow to freshen the lagoon. The sandbar would not be breached during the summer and the lagoon would remain closed until the onset of the rainy season. This would provide suitable water quality throughout the summer months. Higher inflow to the lagoon in October, as well as releases from the flood control storage pools of Lake Sonoma and Lake Mendocino in October, would likely result in a return to open sandbar conditions.

Table 5-35 Predicted Median Flow (50 percent Exceedance) near Hacienda Bridge (RM 20.8) under the Flow Proposal under Current Demand

Water Supply Condition	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
Critical	121	68	41	41	35	38	40	460
Dry	596	327	123	52	65	71	57	169
Normal	1795	672	175	75	67	77	106	302
All	1795	672	188	78	68	78	119	313

Monitoring over a 5-year period has found that each time the sandbar closes, water temperatures increase, DO levels decline, and anoxic conditions form in near-bottom layers (MSC 1997a, 1997b, 1998, 2000; SCWA 2001b). Under the Low-Flow Estuary Management proposal, freshwater inflow would force the salt water out of most of the lagoon, which would restore and stabilize DO levels and water temperatures in the lagoon. With elimination of summertime breaching, the repeated occurrence of poor water-quality events and fluctuating conditions would be eliminated. This is likely to improve summer and fall habitat conditions for salmonids and their invertebrate foodbase over D1610 conditions. The fish species and life-history stage that would most likely benefit is steelhead rearing. Coho salmon may use the lagoon for summer rearing. Both species may utilize the lagoon for rearing because of proximity to spawning and rearing streams in the lower watershed. Chinook salmon migrate out of the system by the end of June, and therefore are less likely to utilize the lagoon for rearing.

When the Flow Proposal is implemented, *dry* season flows reduced, and the sandbar remains closed, dilution of nutrients, and point and nonpoint sources of pollution to the lagoon from agricultural and urban runoff would be reduced (see Section 2.1.2.5). Toxic substances have rarely been detected in Russian River monitoring programs (NCRWQCB 2002a), and therefore are not likely to be an issue in the Estuary. A TMDL for ammonia and DO has been completed for the Laguna de Santa Rosa, the only waterbody in the watershed listed under the CWA 303 (d) list for impairment for nutrients, and implementation is underway to reduce and/or eliminate nutrient sources. No reaches of the mainstem have been listed as impaired for nutrients. Recent additions to the CWA Section 303(d) list include the Russian River Guerneville HSA for pathogens because the river sometimes exceeds water-quality objectives for fecal coliforms near Healdsburg Memorial Beach and Monte Rio Beach in the summer (NCRWQCB 2001b). Treated sewage is not discharged in the watershed during the summer months (SCWA 1998a). Nonpoint-source discharges from failing septic systems along the Russian River have not been fully identified.

With the elimination of tidal flushing and reduction of flows in the lower river, dilution of pollutants may be reduced. Although dilution of pathogen loading to the lagoon may be lower than under baseline conditions, there are no data that indicate fecal coliform levels are high, aside from the two summer beach locations noted above (Healdsburg Memorial and Monte Rio beaches). Therefore, this may not have negative effects on salmonids.

Juvenile Rearing

Implementation of the Low-Flow Estuary Management proposal would improve rearing habitat over baseline conditions by stabilizing water quality, water levels, and shoreline vegetation, and by improving the invertebrate foodbase. Steelhead currently utilize the Estuary for rearing, and therefore are most likely to benefit from improved summer rearing habitat. Primary coho salmon rearing habitat is found in tributaries rather than in the Estuary, and therefore may not realize substantial benefits, but coho salmon may also utilize the lagoon. Chinook salmon juveniles may rear for a period of time in the Estuary, but in most years would likely emigrate before the sandbar closes.

As discussed previously, rapid or fluctuating changes in salinity and water quality can have substantial effects on the invertebrate foodbase. The proposed action would allow a freshwater-dominated system to develop, stabilizing water quality during periods when the lagoon is closed, thereby improving rearing habitat conditions. Balancing rates of inflow with natural seepage through the sandbar, losses from evaporation, and tidal influences would allow maintenance of suitable habitat quality.

The Flow Proposal could increase water temperature of summer inflow to the lagoon. High summer water temperatures naturally occur in the lower Russian River. However, coastal influences in the Estuary and lower mainstem tend to reduce summer water temperatures. While water temperatures in the mainstem downstream of the Mirabel facilities may increase under the Flow Proposal or during *dry* and *critically dry* water years, a reduction in warmwater inflow to the Estuary may help offset temperature effects in the lagoon.

Overall, the proposed management program is likely to result in a more stable ecosystem that would improve summer rearing habitat over conditions under D1610. Stable conditions would result in better water-quality conditions, improve primary productivity and the invertebrate foodbase, and stabilize marsh and shoreline vegetation.

Juvenile Outmigration

Juvenile coho salmon, steelhead, and Chinook salmon pass through the Estuary during their outmigration period. Steelhead smolts caught during the 5-year monitoring study were very fit and plump, suggesting they may be feeding while in the Estuary (MSC 2000).

Under baseline conditions, most sandbar closures occur in the late summer and early fall. Under the Flow Proposal, the sandbar may close in the spring or early summer in some years, depending on inflow to the lagoon and ocean conditions. Without artificial breaching, downstream migrants may not be able to emigrate until fall. The end of the Chinook salmon downstream migration period occurs in June, and under the Low-Flow Estuary Management program, the sandbar may close in June in some years. Peak Chinook salmon downstream migration occurs earlier in the spring, but juvenile fish at the end of the season may be trapped in the lagoon for the summer. However, inflow to the Estuary would be reduced after primary downstream migration periods for all three species, and therefore, potential effects on juvenile outmigration are likely minimal. Effects are most likely to occur during *critically dry* years when low flows may result in spring sandbar closures. As habitat conditions in the lagoon improve, juvenile fish would benefit from additional rearing time in the food-rich environment that develops.

Predation

Artificial breaching creates a passageway that could potentially concentrate juvenile or adult salmonids. This may affect the level of pinniped or avian predation. By eliminating artificial breaching during the summer, the risk of predation would be reduced.

5.3.10.5 Storm-Flow Estuary Management

The biological effects of artificial breaching events during the rainy season are evaluated for early-season and late-season breaches.

Early-Season Breach Events

Early-season artificial breach events are defined as breaches that occur at the onset of the rainy season (see Section 4.3.3). Sandbar breaching has the potential to flush juvenile salmonids out of the Estuary before they are ready to go.

One of the protocols that can minimize effects to salmonids in the lagoon during the fall/winter season is to implement artificial breaching as close as possible to the time when a natural breach might occur. Early season breaches would only be conducted if runoff from a rainfall event is likely to result in a WSE greater than a target of 8 feet, to avoid flooding of local properties that would occur at WSE greater than 10 feet. Therefore, timing of artificial breaches would occur as closely as possible to naturally occurring breaching events.

Data are not available to determine at what WSE the sandbar would likely breach naturally, and it would vary depending on flow and ocean conditions as well. However, by timing artificial breaching to the onset of winter rains and delaying breaching activities as late as possible, the breaching program will approximate the natural breaching schedule to the fullest extent possible while maintaining flood protection to surrounding properties. Once the sandbar is breached, tidal flushing would create salinity gradients within the Estuary for juvenile salmonid acclimation before emigration. Juvenile fish that have not been acclimated to salt water would be able to move to fresher surface waters or move upstream. Some steelhead that rear in the lagoon for the summer, or late Chinook salmon migrants that may have been trapped when the sandbar closed, would emigrate in the fall.

SCWA staff's observations during artificial breaching events suggest that, while water velocity within the breach channel is very high, velocity in the Estuary is not (S. White, SCWA, pers. comm. 2000). A hydraulic head between low tide and gage heights up to 7.5 feet creates a rush of water when the berm is first breached. The trench is about 10 feet wide and a couple of feet deep when first dug, but by the time the water has slowed the channel can be 100 feet wide. However, water velocities in the Estuary appear to be nondetectable. Gulls have been observed floating on the water 50 to 100 feet from the breach. Seals swim within 20 feet of the wash, avoiding the channel. These observations suggest that the risk of juveniles being flushed out during a breaching activity is low.

In the past, local residents have conducted unauthorized breaching. They are likely to do so in the future if threats to local property occur, which could result in infrequent summertime breaching that could negatively affect salmonid habitat. By generally keeping the WSE at approximately 7 feet or less during the dry season, the probability of such illegal breaching events would be reduced.

Late-Season Breach Events

Late-season breach events are events that occur near the end or after the end of the rainy season. Because water-quality conditions in the lagoon during summer appear to be an important factor for steelhead rearing in the lagoon, late-season breaches are examined for possible impacts on water quality. Factors that most likely influence water-quality conditions during the summer include:

- The amount of salt water in the lagoon when the sandbar forms and closes the lagoon.

- The amount of freshwater inflow immediately following lagoon closure and the amount of inflow during subsequent weeks.

- The rate of water loss from the lagoon through sandbar seepage, evaporation, and evapotranspiration (loss of salt water through the bottom layer, and fresh water from surface layer).

Late-season breaching is of particular concern if it occurs when summer flow is reduced. Under these conditions, freshwater inflow may be expected to convert the water in the lagoon from salt water to fresh water at a slower rate, and if flow were low enough or the breach were late enough in the season, the lagoon may not freshen at all.

Under the Flow Proposal, the Russian River would be managed so that sufficient river flow is available to freshen the lagoon relatively quickly and early in the season so that good water-quality conditions could be stabilized throughout the summer.

Water Quality near Willow Creek

A fish kill was documented in 1992 when breaching occurred at WSE levels of over 9 feet and a flush of anoxic water drained out of Willow Creek into the Estuary (RREITF 1994). The current Estuary Management Plan breaches the sandbar between 4.5 and 7 feet and prior to storm events. Fish kills due to poor water quality have not been documented under baseline conditions.

Although the cause of this anoxic water is not known, there are a couple of factors to consider. One is that when the WSE begins to rise after the sandbar is closed, terrestrial vegetation is submerged, dies, and contributes to biological oxygen demand, degrading water quality in the marsh in Willow Creek. Another factor is the mobilization of anoxic bottom layers in Willow Creek when the sandbar was breached at WSE levels above 9 feet.

This would likely be avoided under the proposed project because artificial breaching would generally occur at WSE levels below 8 feet and when the river stage is rising. Because sandbar breaching would be delayed until a rainfall event results in increasing stage elevations, potential flushes of poor quality water from Willow Creek would be diluted, thereby reducing the risk. Furthermore, if the WSE in a lagoon is maintained at a stable level, aquatic vegetation would become established, contributing to higher DO levels in lower Willow Creek Marsh or shallow water habitats at other tributaries. In this case, water quality could improve in the marsh.

Juvenile and Adult Migration

Artificial breaching has the potential to cause juvenile salmonids to be swept out of the Estuary before they are physiologically ready to migrate to the sea. Steelhead that rear in the Estuary during the summer, as well as late Chinook salmon migrants, may need some time to acclimate to salt water before emigrating to the ocean in the fall. As discussed earlier, by concentrating artificial breaching to a time when it would naturally occur at the onset of winter rains, this risk would not be substantially higher than occurs under natural breaching events. SCWA staff observations during past artificial breaching events suggest that the risk of juveniles being flushed out during a breaching activity is low. When salinity gradients have formed in the Estuary, juvenile fish would be able to move to fresher surface waters or move upstream.

Upstream migration periods for adult coho salmon and steelhead occur much later in the year than for Chinook salmon, so artificial breaching would most likely affect adult Chinook salmon migration. Although peak migration for Chinook salmon occurs in October to November, adult Chinook salmon have been documented at the Mirabel inflatable dam as early as late-August. A key consideration is whether passage conditions in the river are suitable when the sandbar is breached.

Under baseline conditions, artificial breaching provides earlier passage opportunities for adult Chinook salmon and early migrants may enter the river prematurely, when flow is low and water temperature high. Under the proposed project, the sandbar would be breached as close as possible to when a natural breach is likely to occur, when the river stage is rising and passage conditions in the river are more suitable.

Predation and Changes in Angling Pressures or Poaching

Currently, there are large self-sustaining populations of harbor seals, and occasionally California sea lions and elephant seals appear in low numbers. Their peak populations tend to occur in the late winter and mid-summer (MSC 2000), which coincides with adult and smolt migration periods. Pinniped predation is a natural occurrence during these times. The sandbar would be artificially breached for storm-flow management as close as possible to a time when it would naturally breach, and therefore, it is not likely to substantially increase the risk over natural conditions.

Artificial breaching may potentially increase incidental angling pressure or poaching opportunities on adult salmonids, particularly Chinook salmon. An artificial breach in August or September may produce a freshwater outflow that attracts Chinook salmon into the river prematurely. If the fish are trapped in areas of low-flow or high water temperatures that stress them, they may be more likely to be caught. When artificial breaching is delayed to a time when rainstorms are likely to result in rising river stage the risk of angling pressure or poaching to adult Chinook salmon is lower than D1610 conditions.

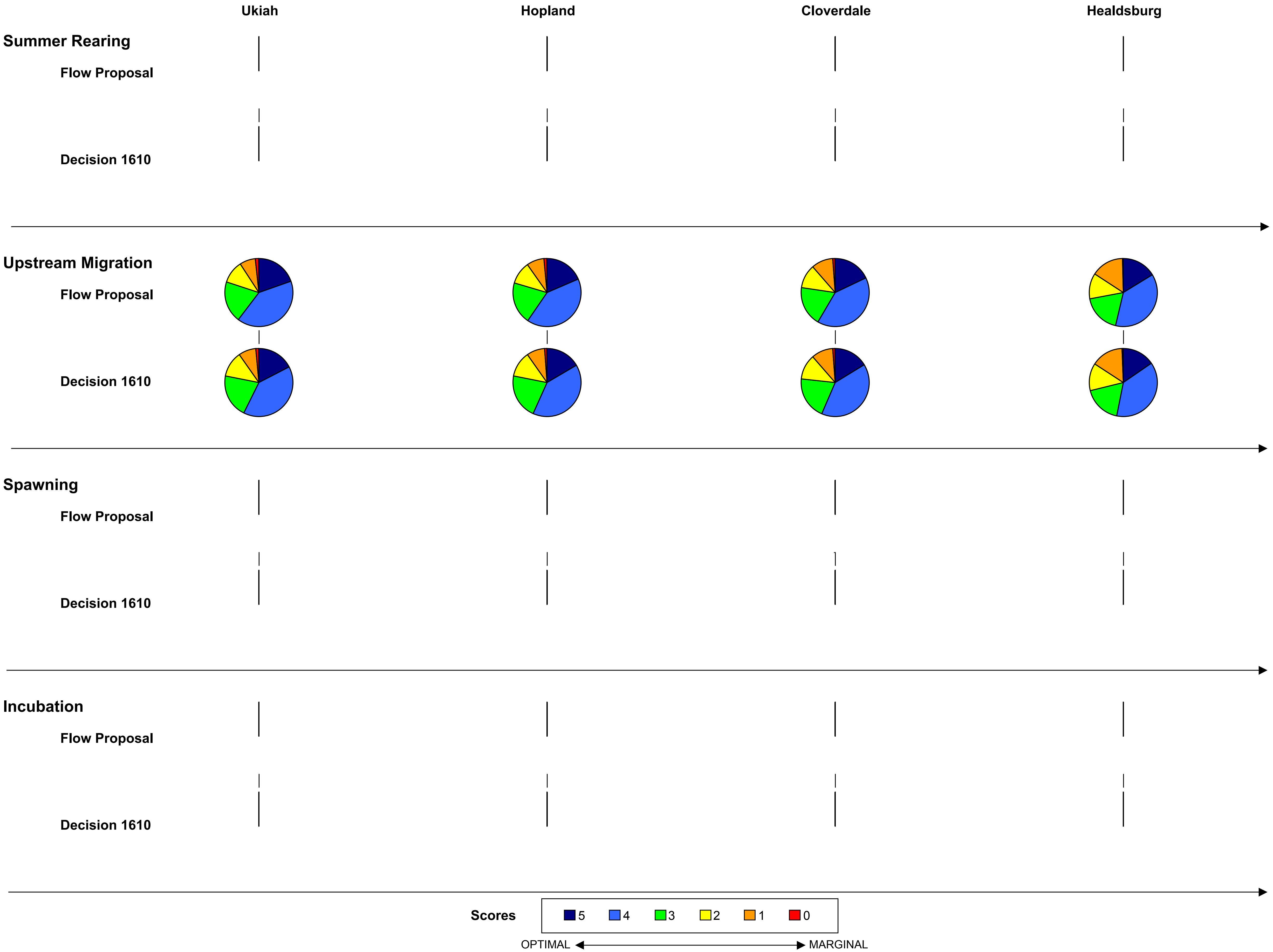


Figure 5-7 Coho Flow Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

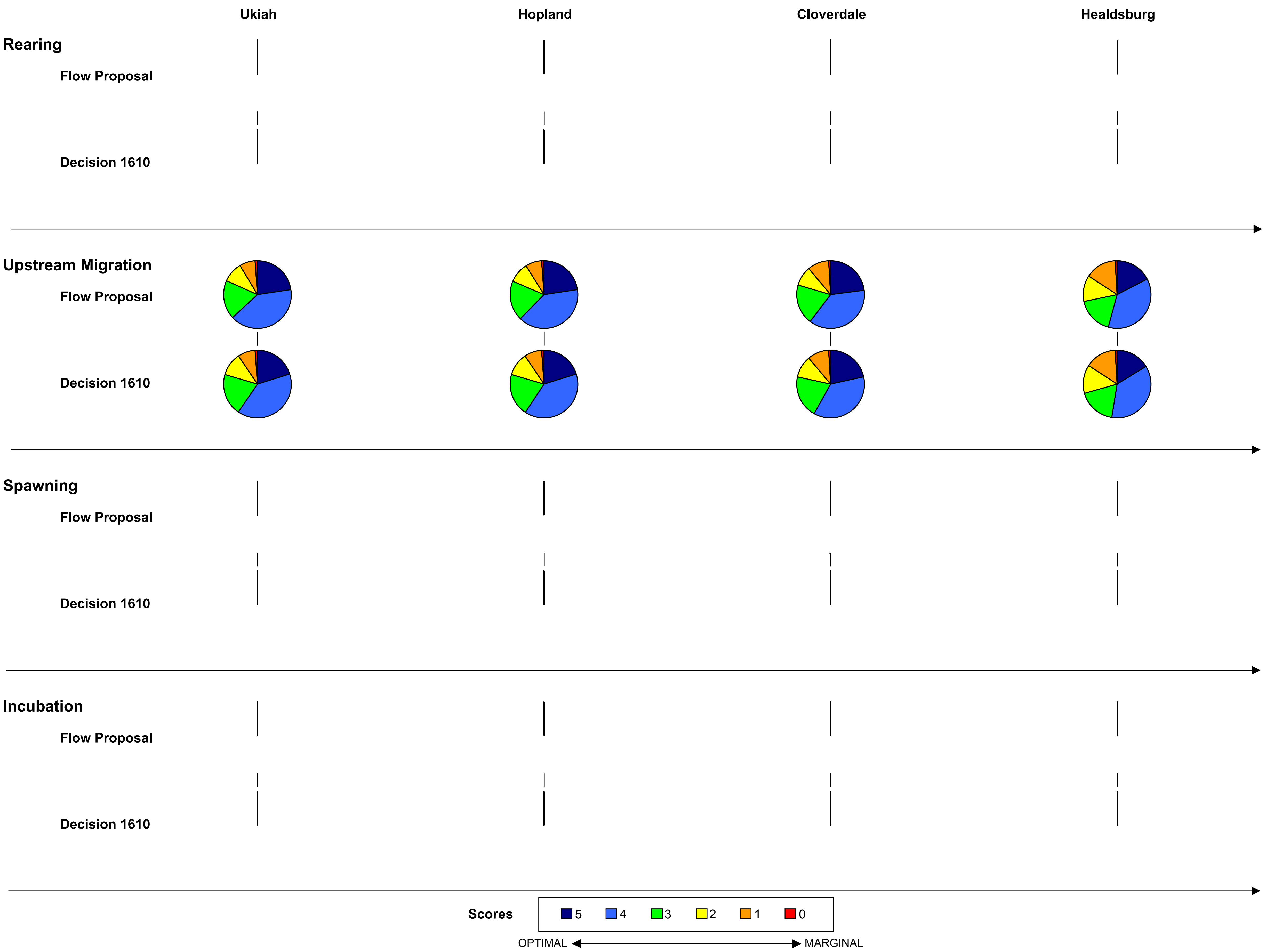


Figure 5-8 Coho Flow Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

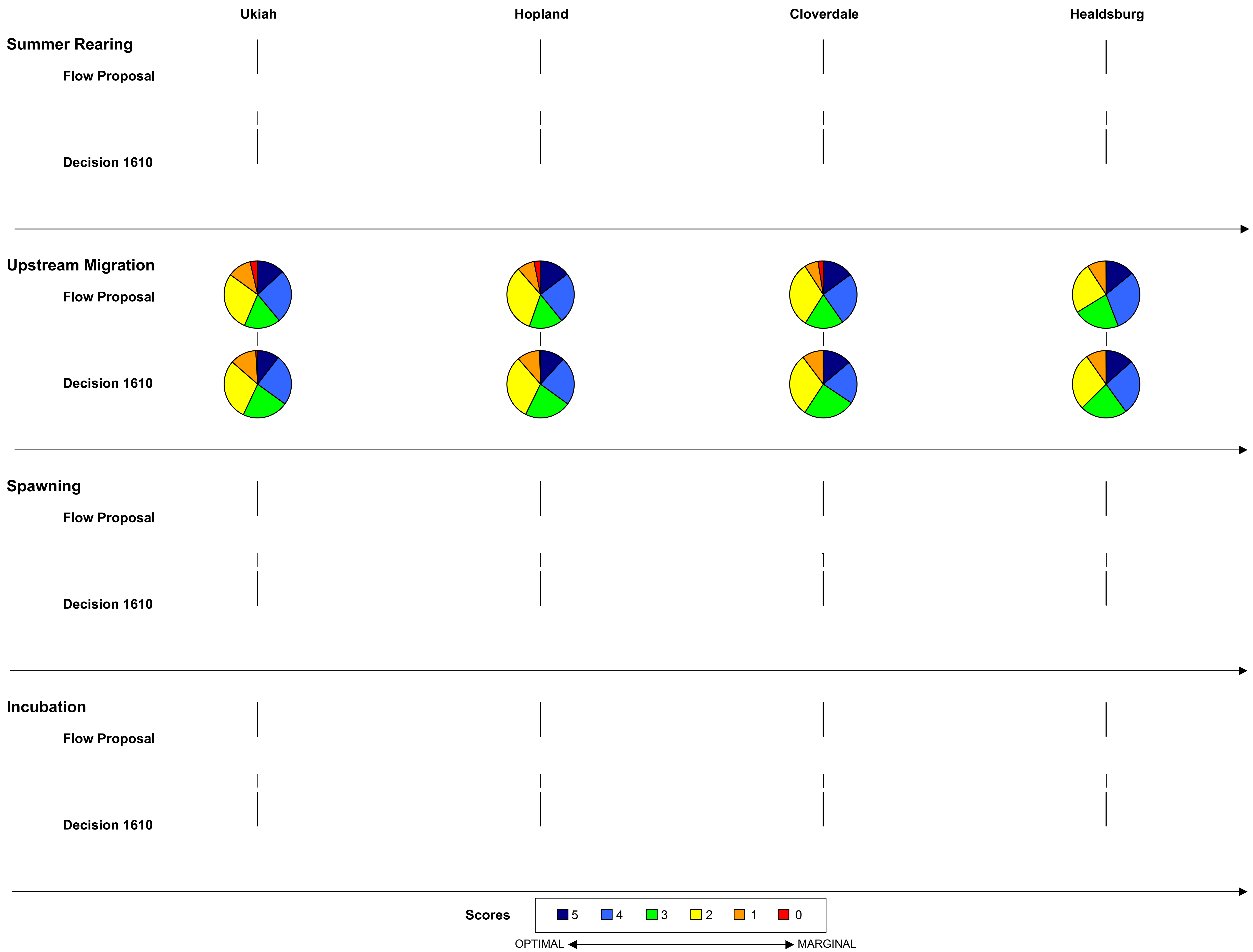


Figure 5-9 Coho Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

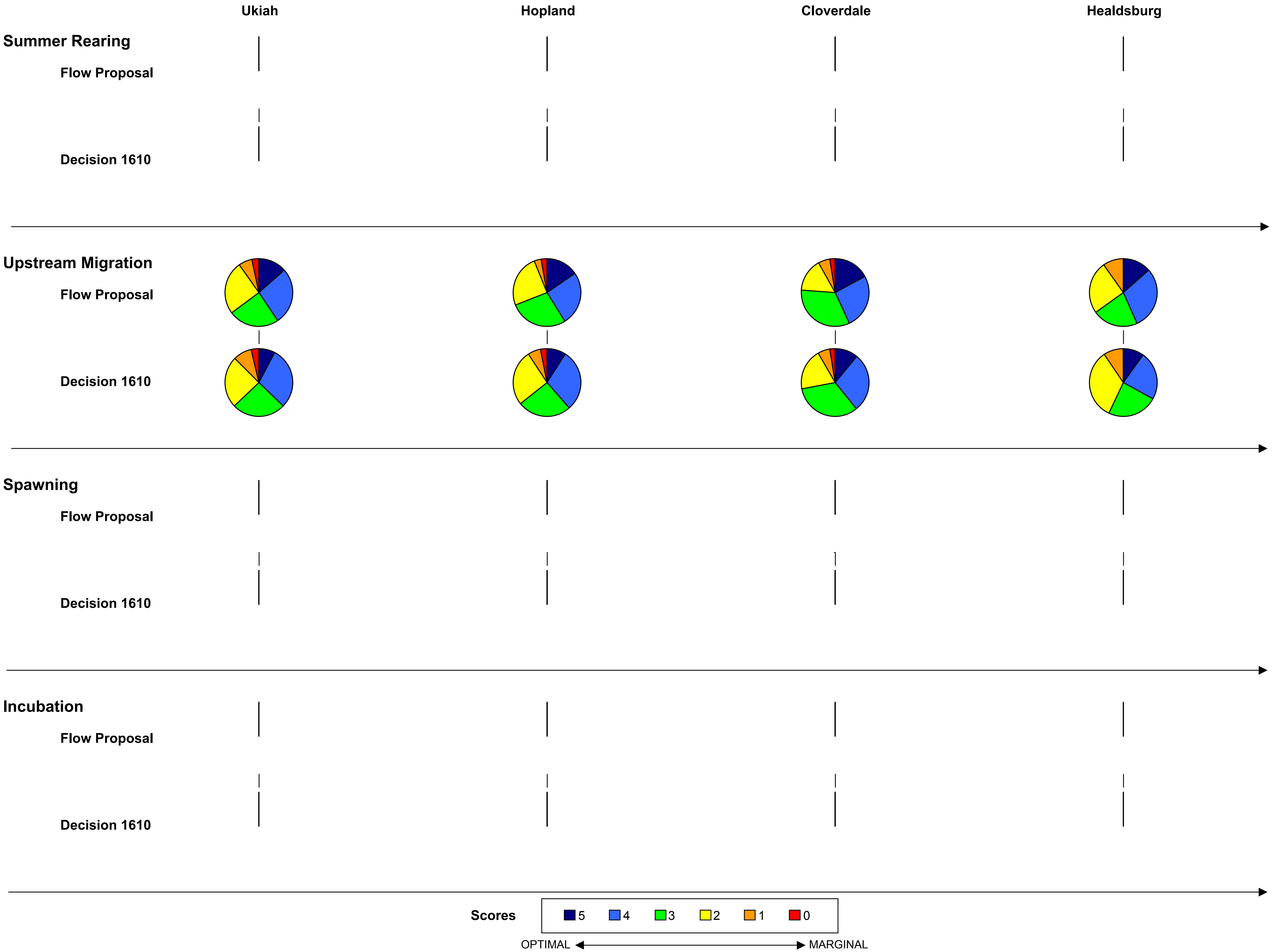


Figure 5-10 Coho Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

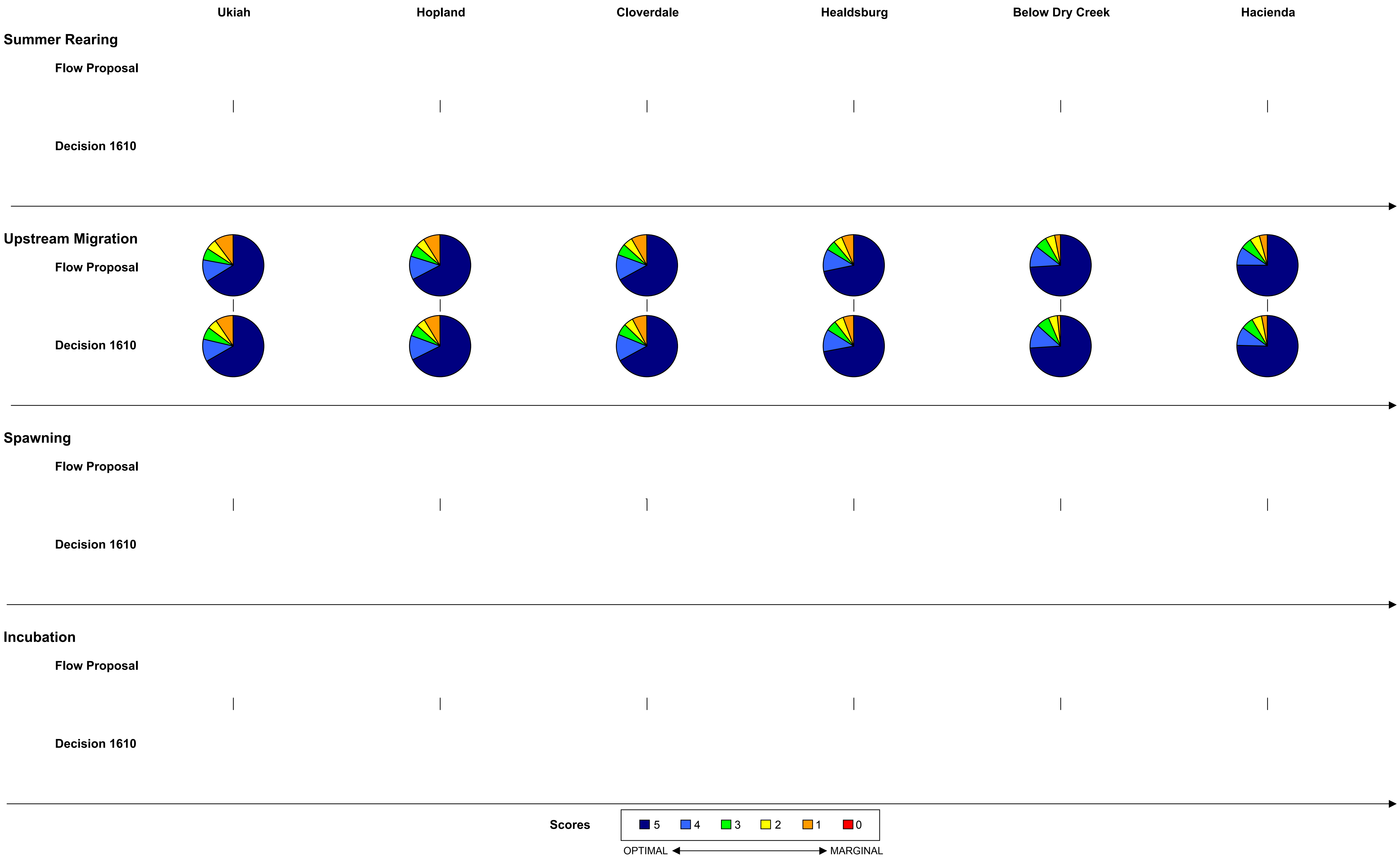


Figure 5-11 Coho Temperature Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

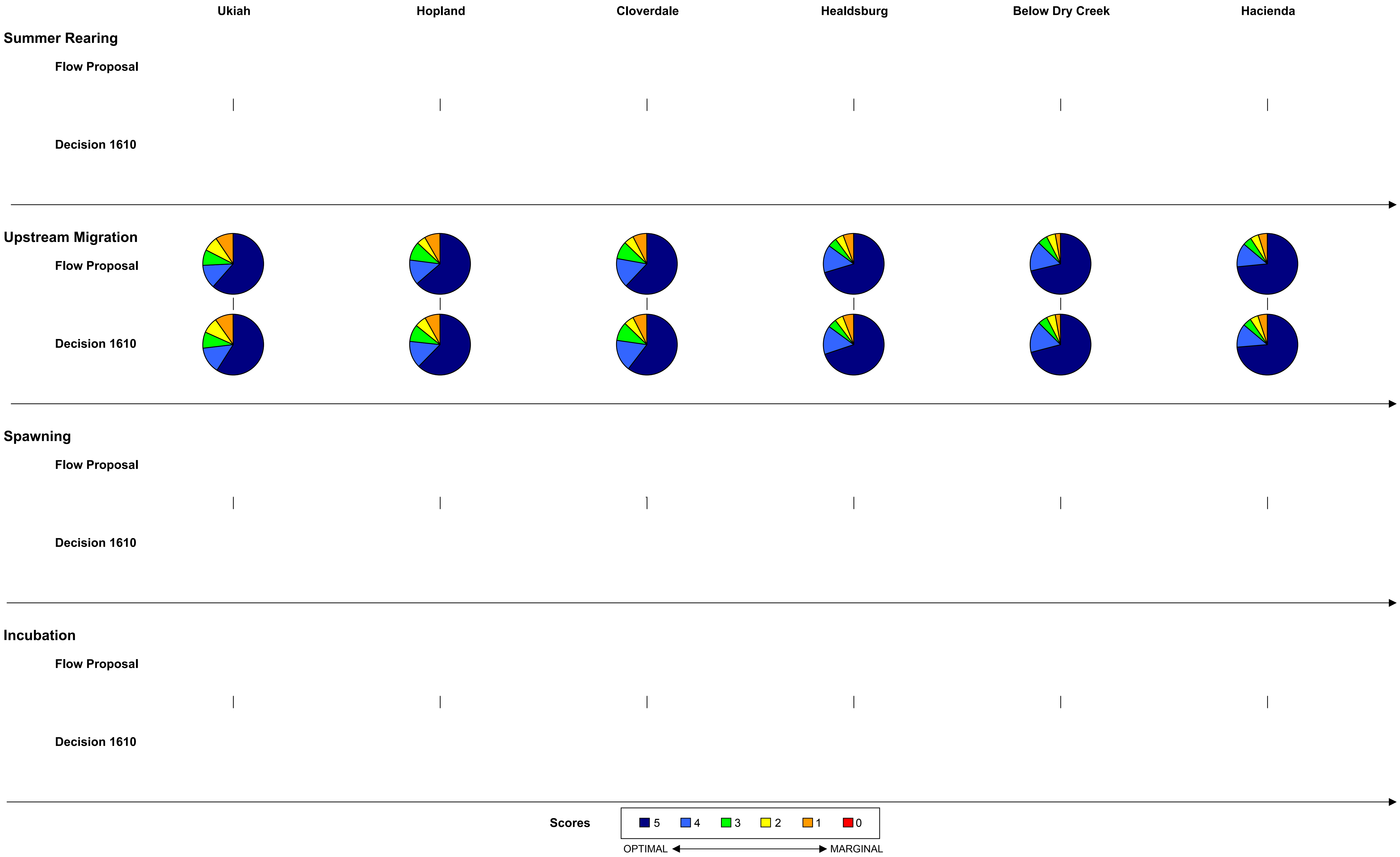


Figure 5-12 Coho Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

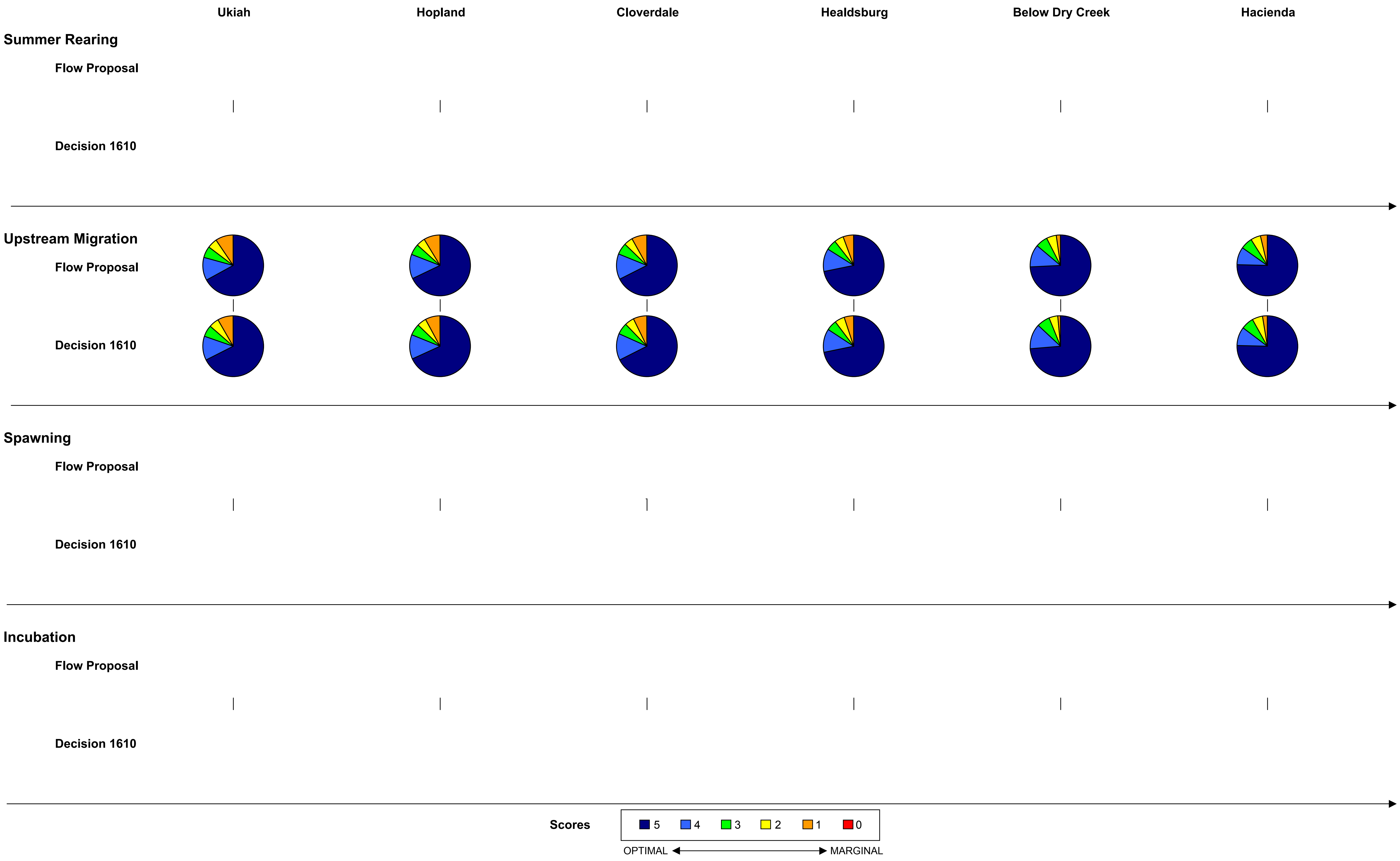


Figure 5-13 Coho Temperature Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

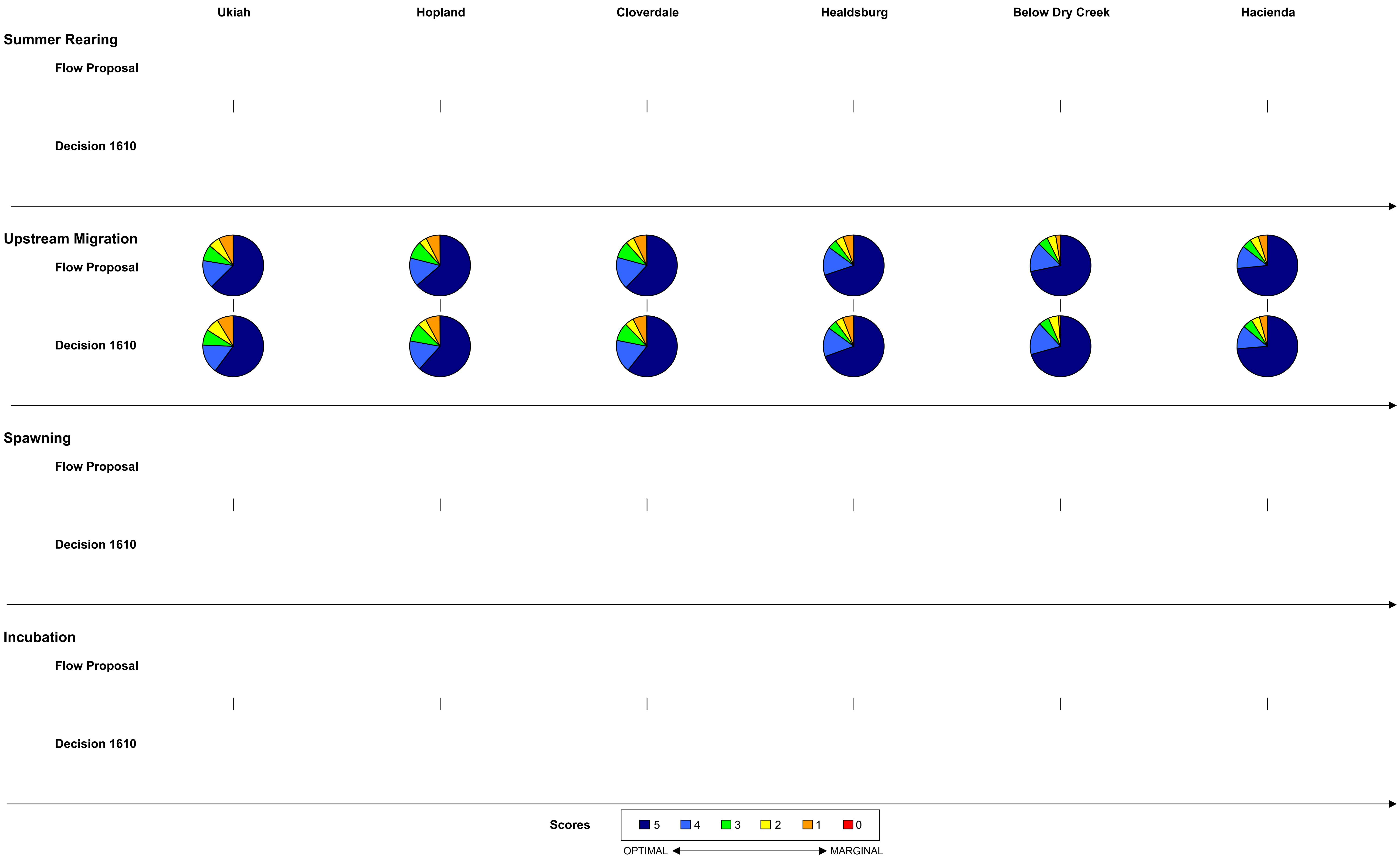


Figure 5-14 Coho Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

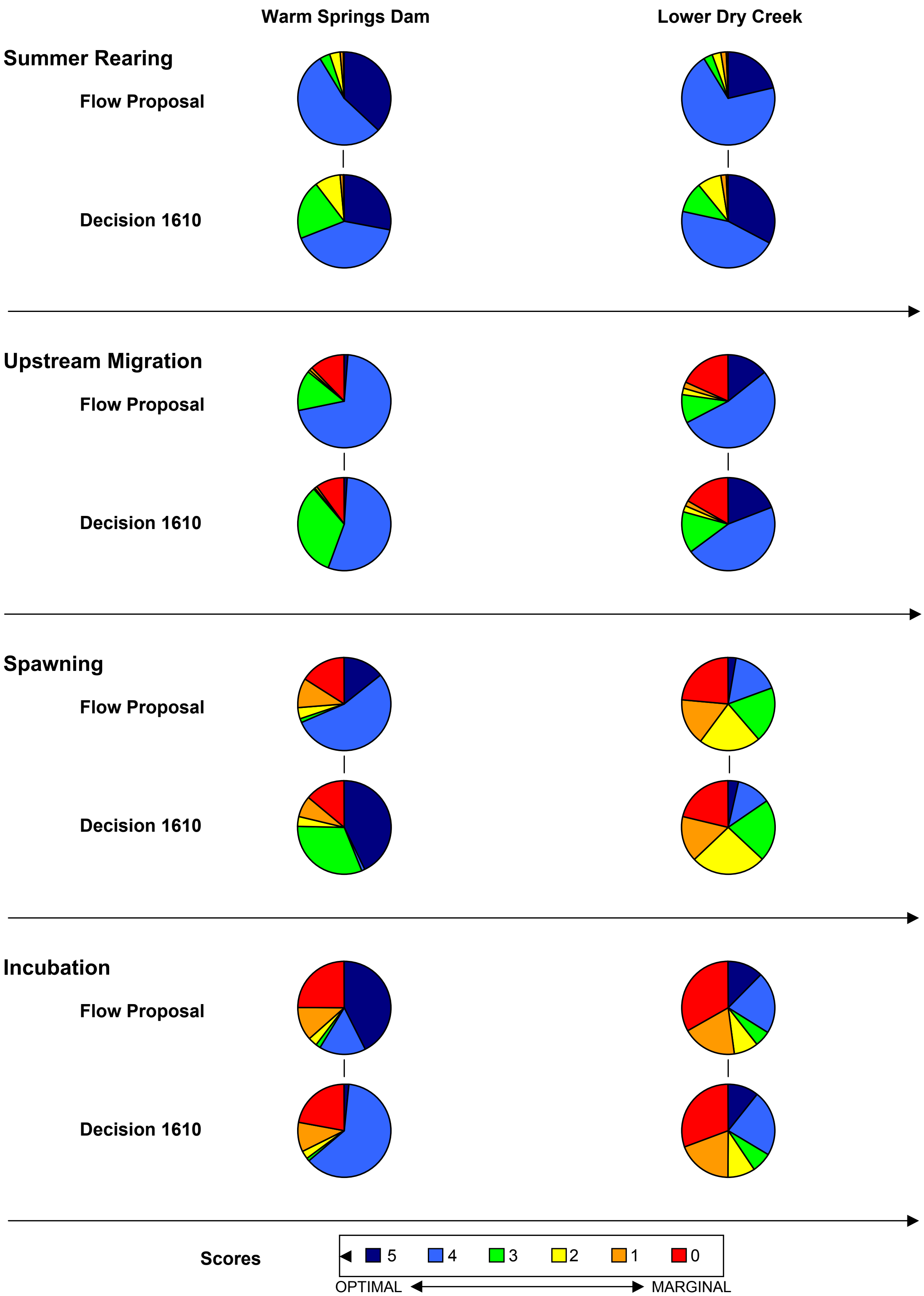


Figure 5-15 Coho Flow Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

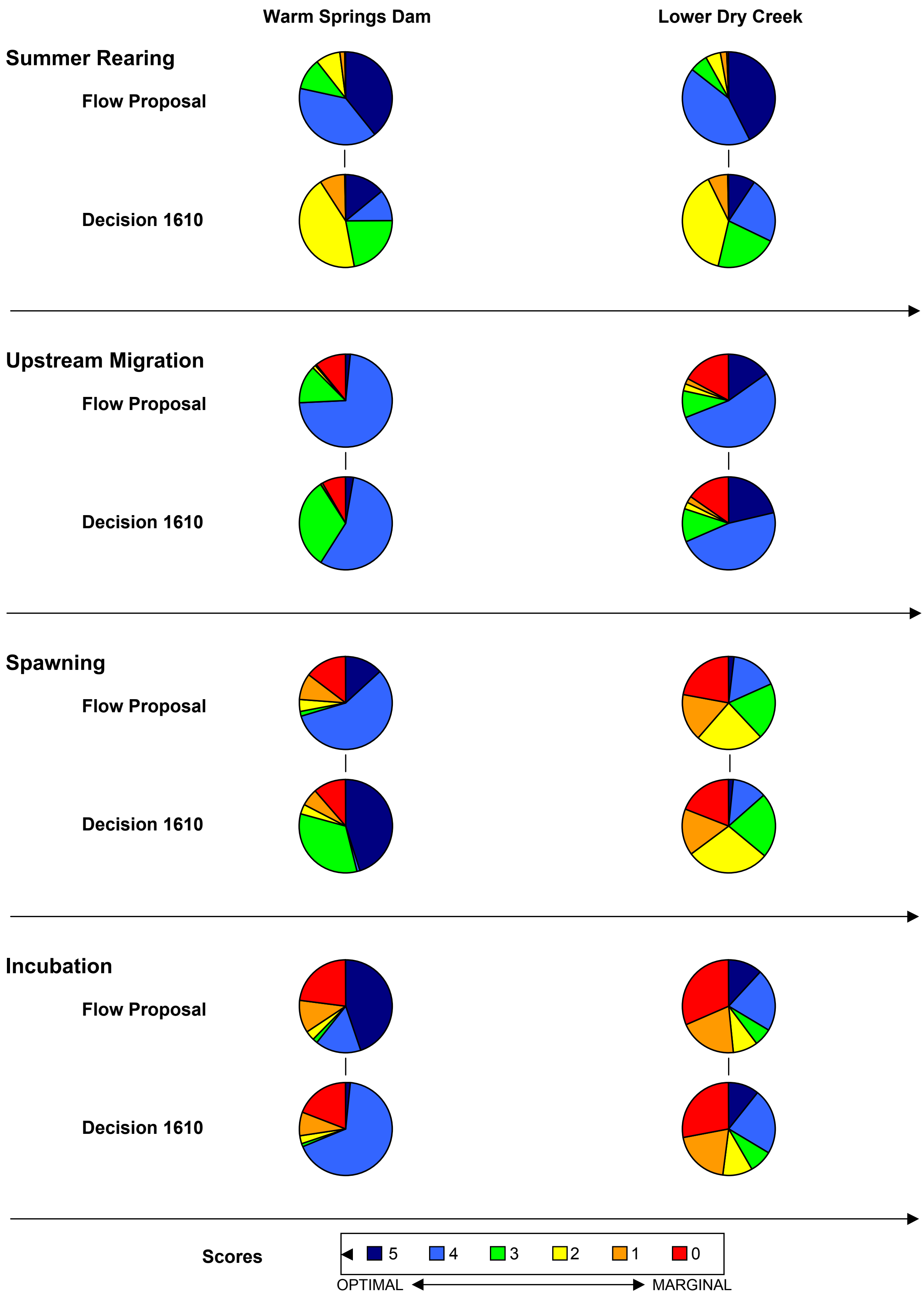


Figure 5-16 Coho Flow Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

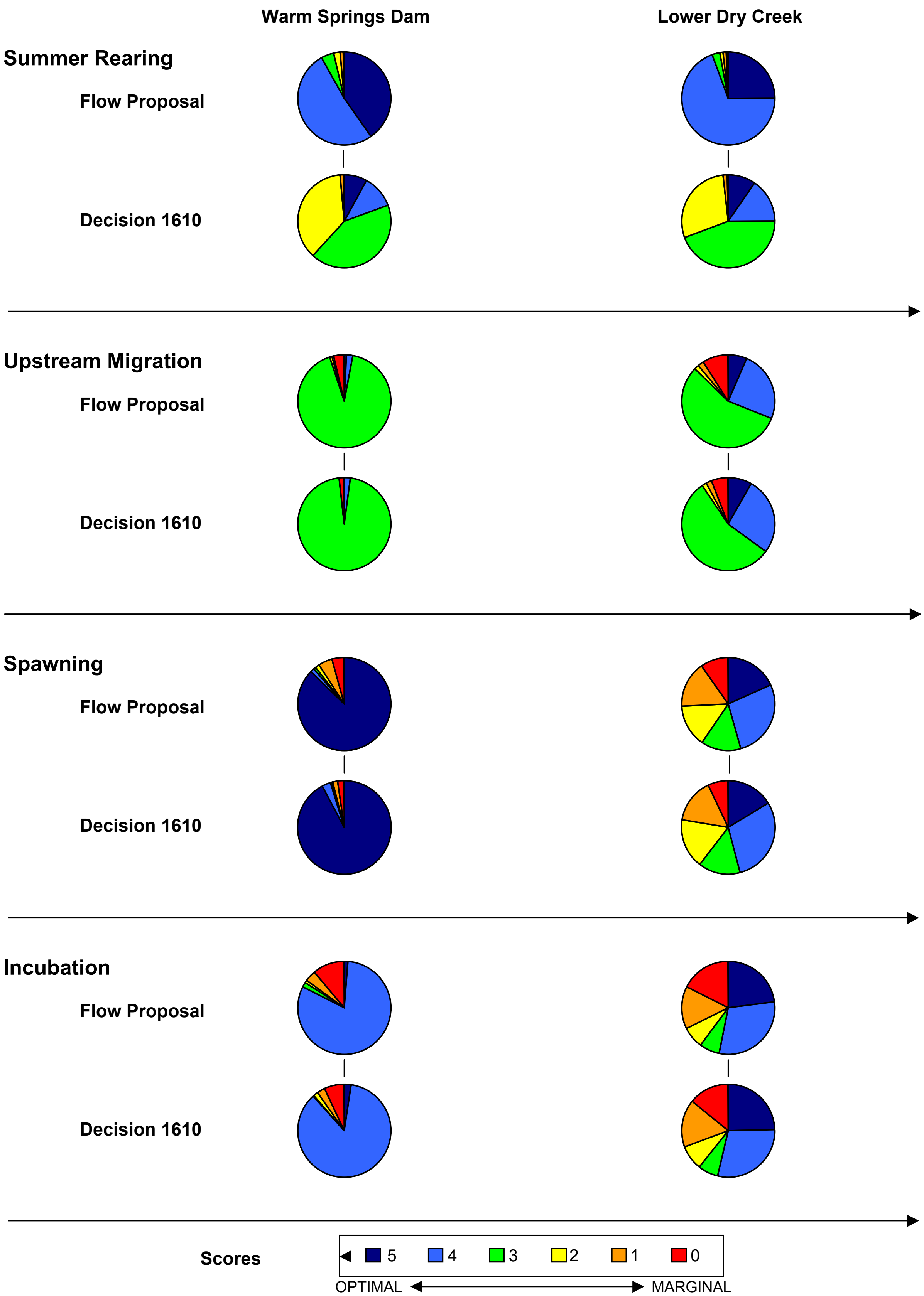


Figure 5-17 Coho Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

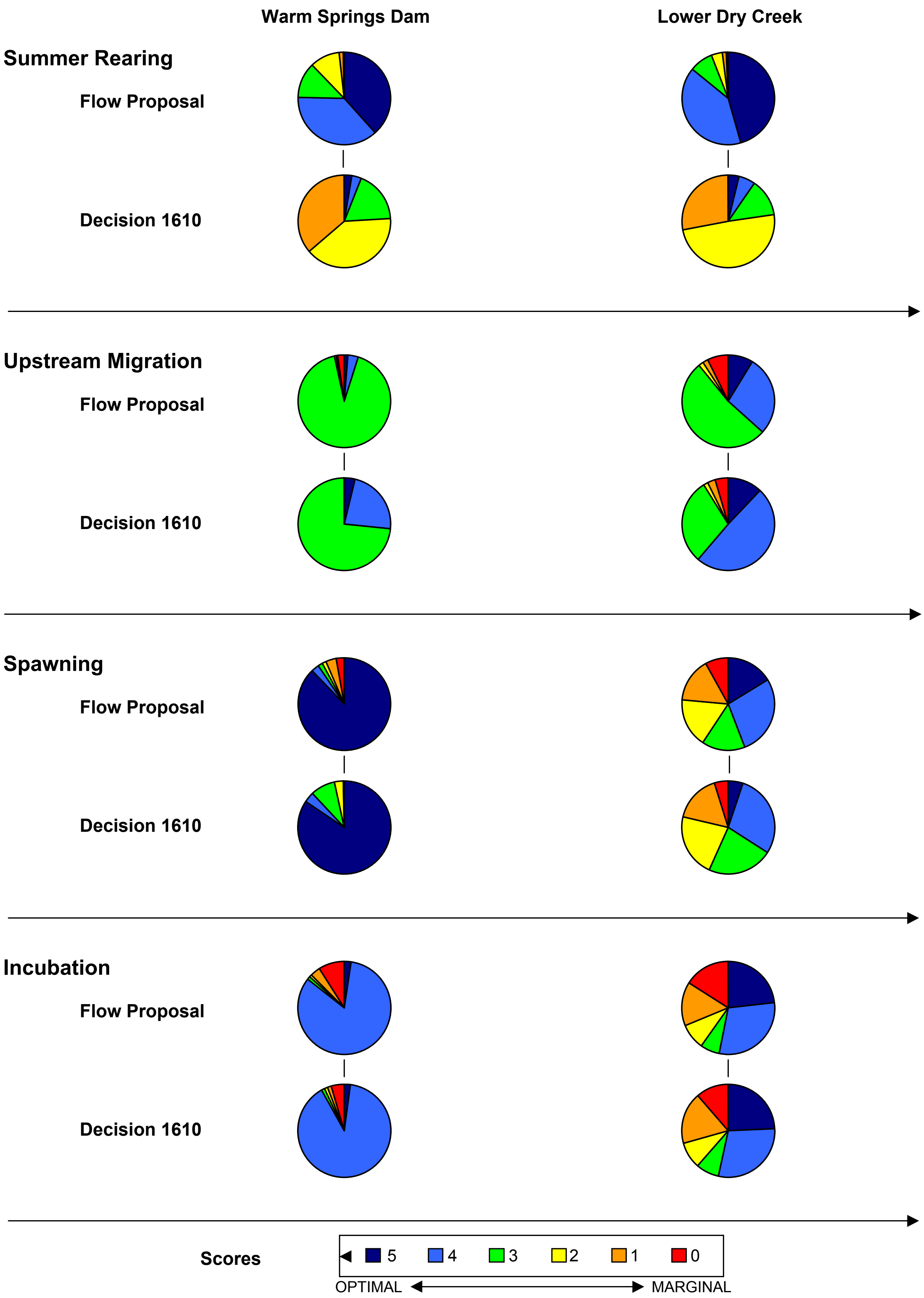


Figure 5-18 Coho Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

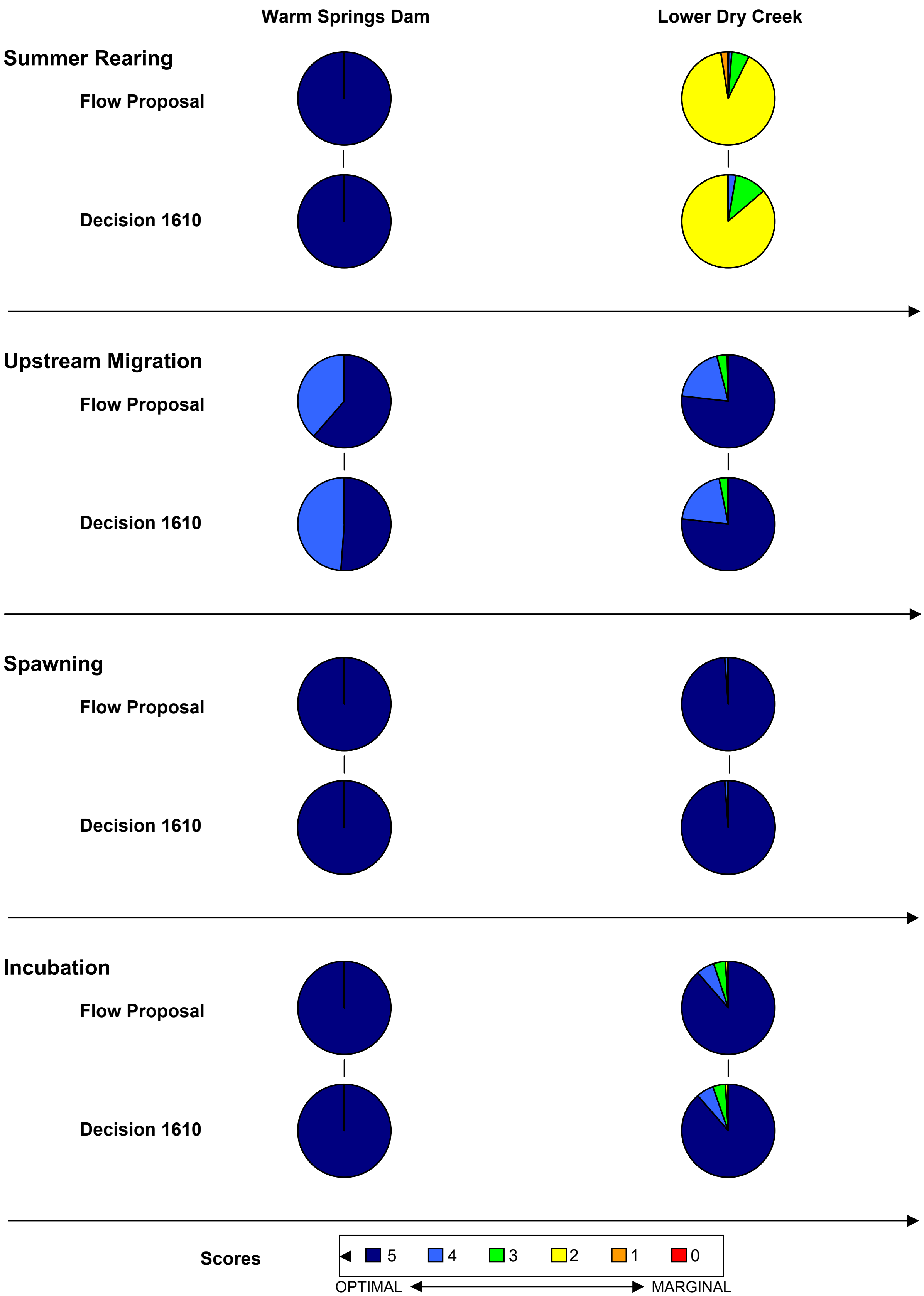


Figure 5-19 Coho Temperature Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

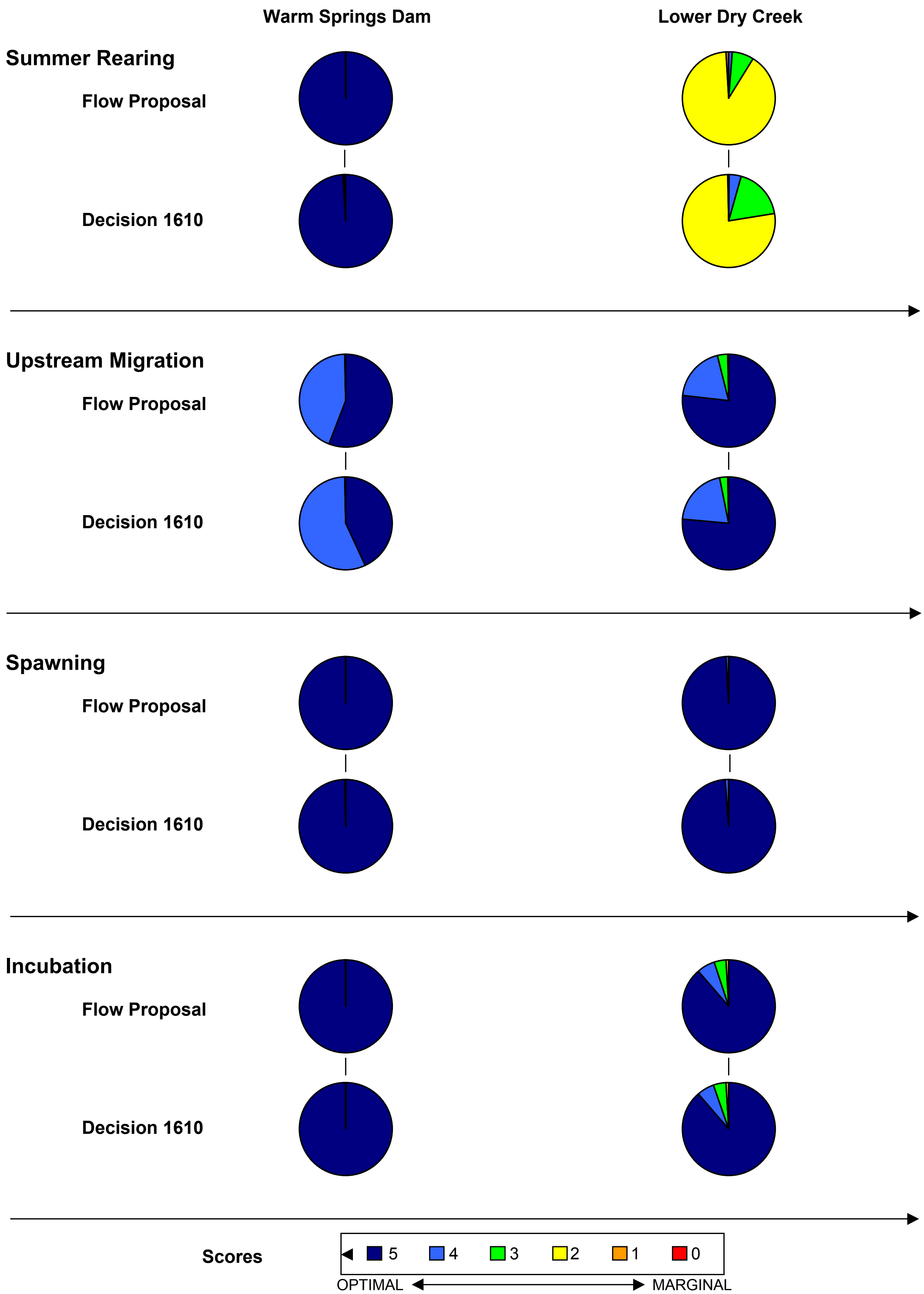


Figure 5-20 Coho Temperature Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

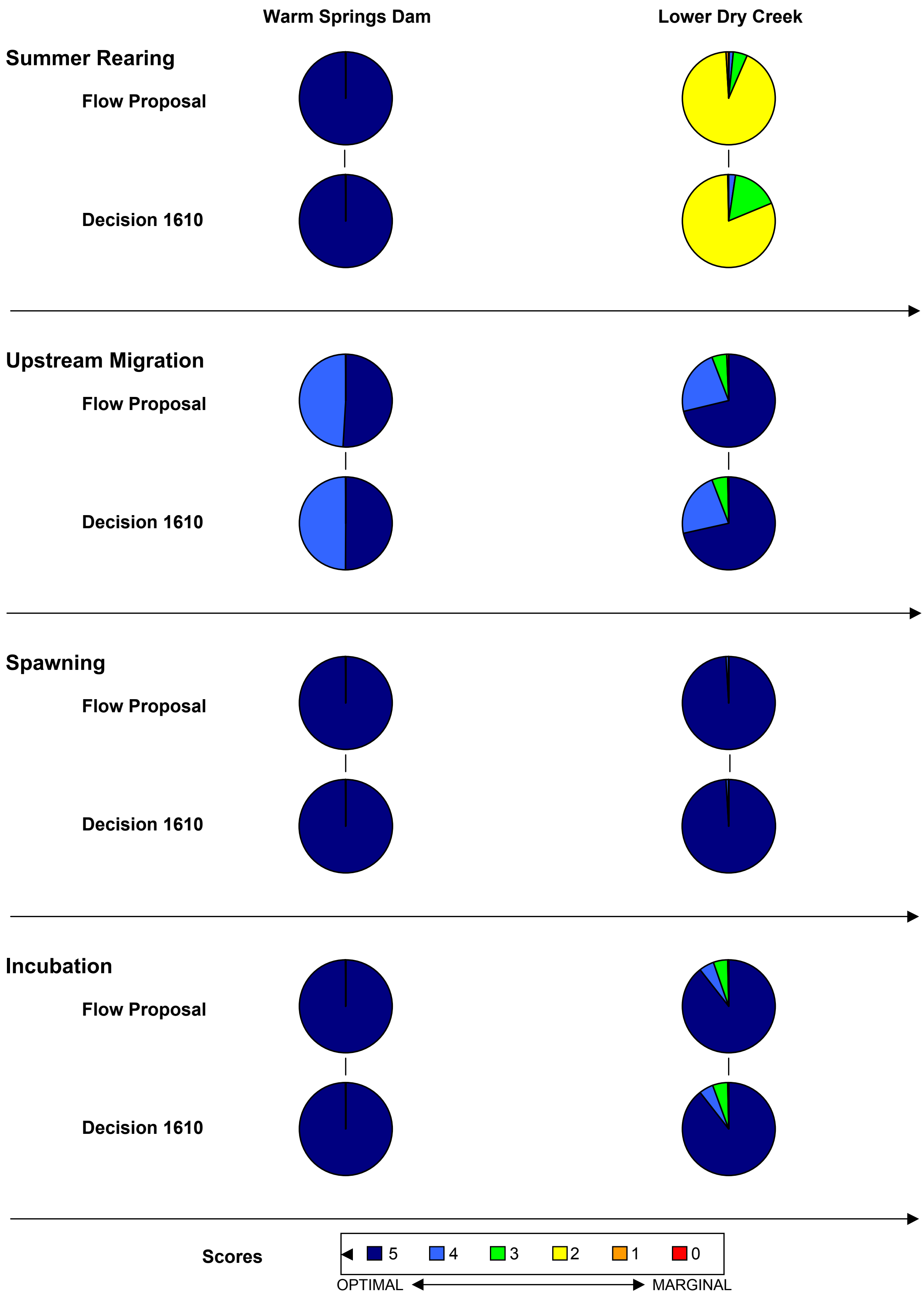


Figure 5-21 Coho Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

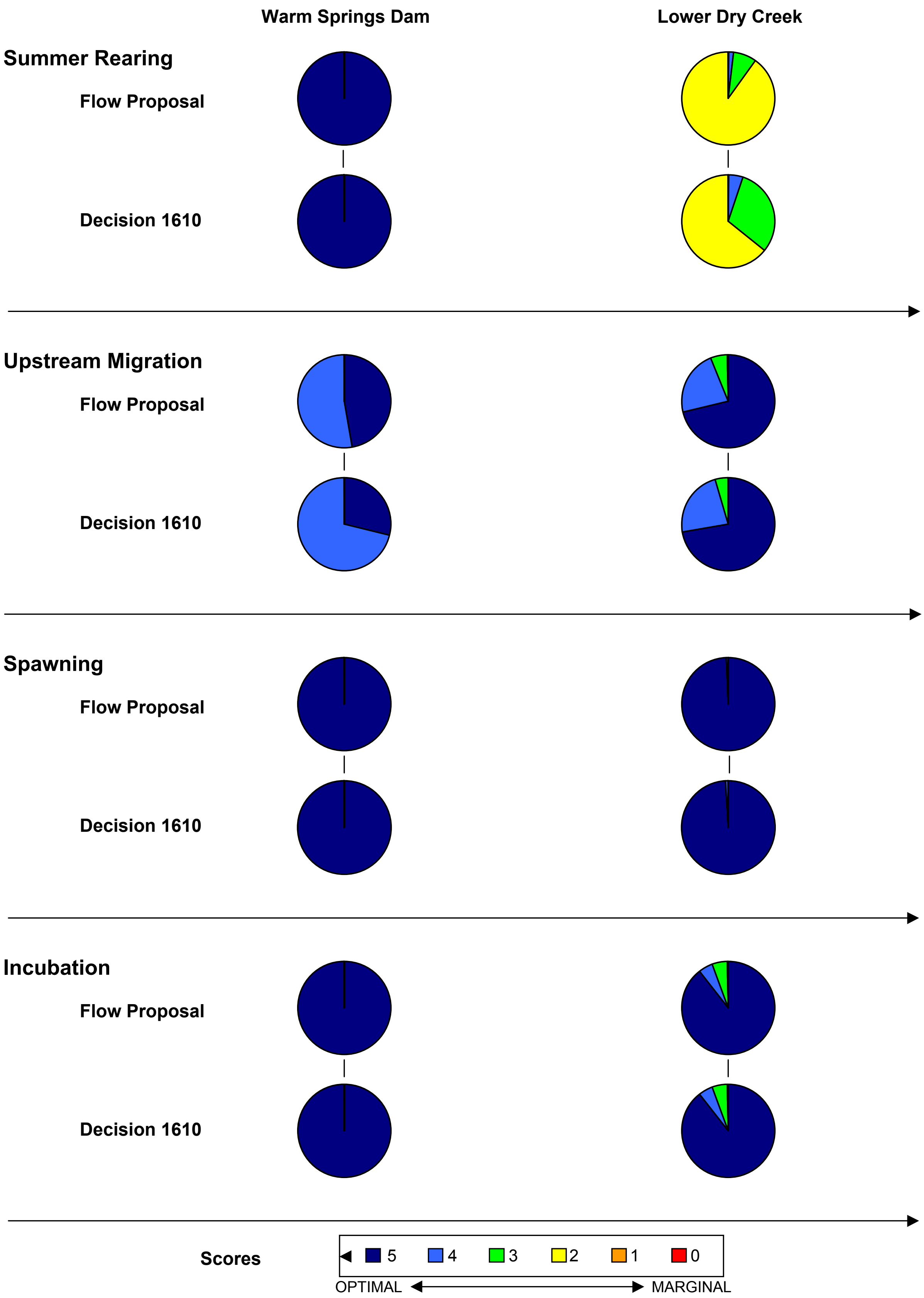


Figure 5-22 Coho Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

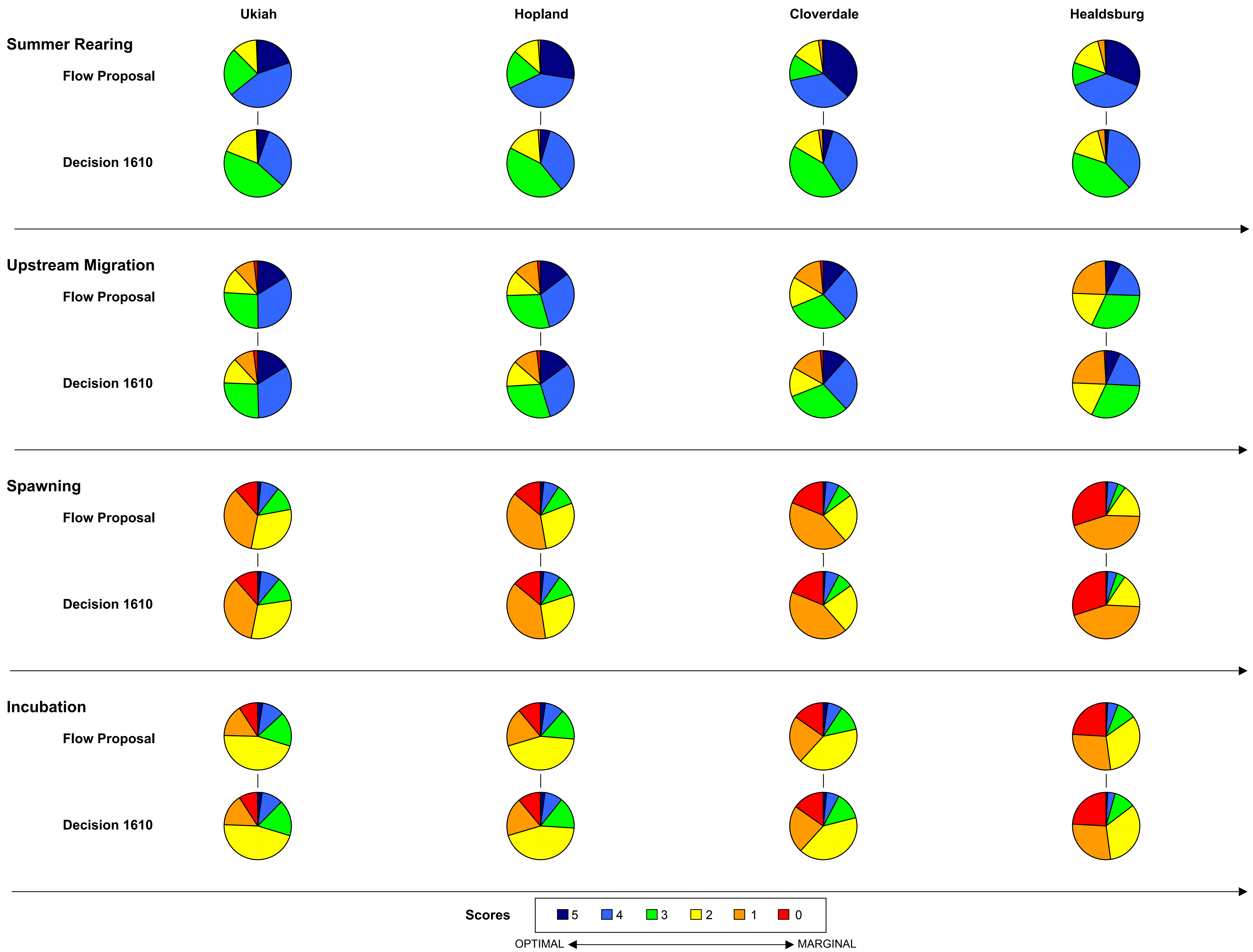


Figure 5-23 Steelhead Flow Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

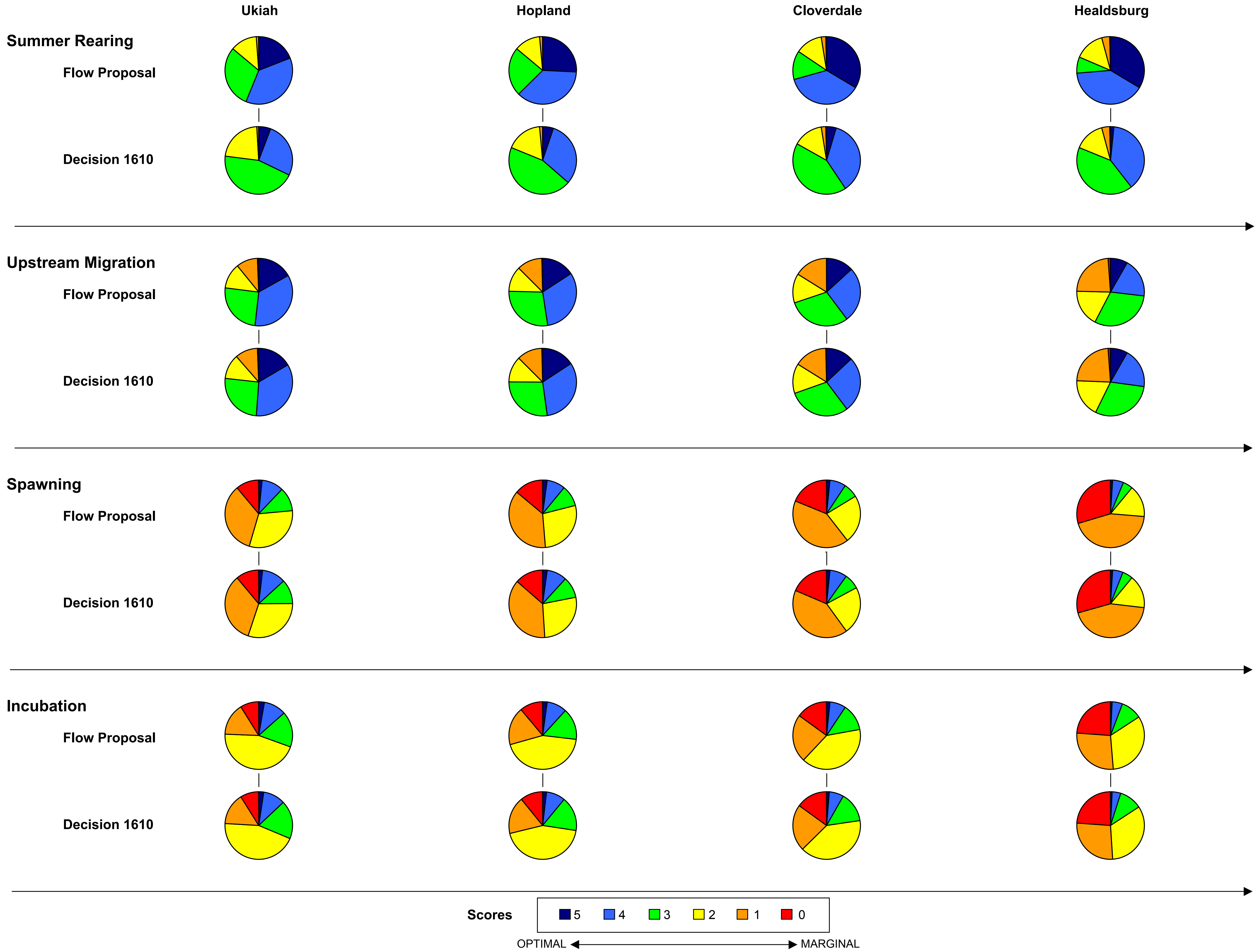


Figure 5-24 Steelhead Flow Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

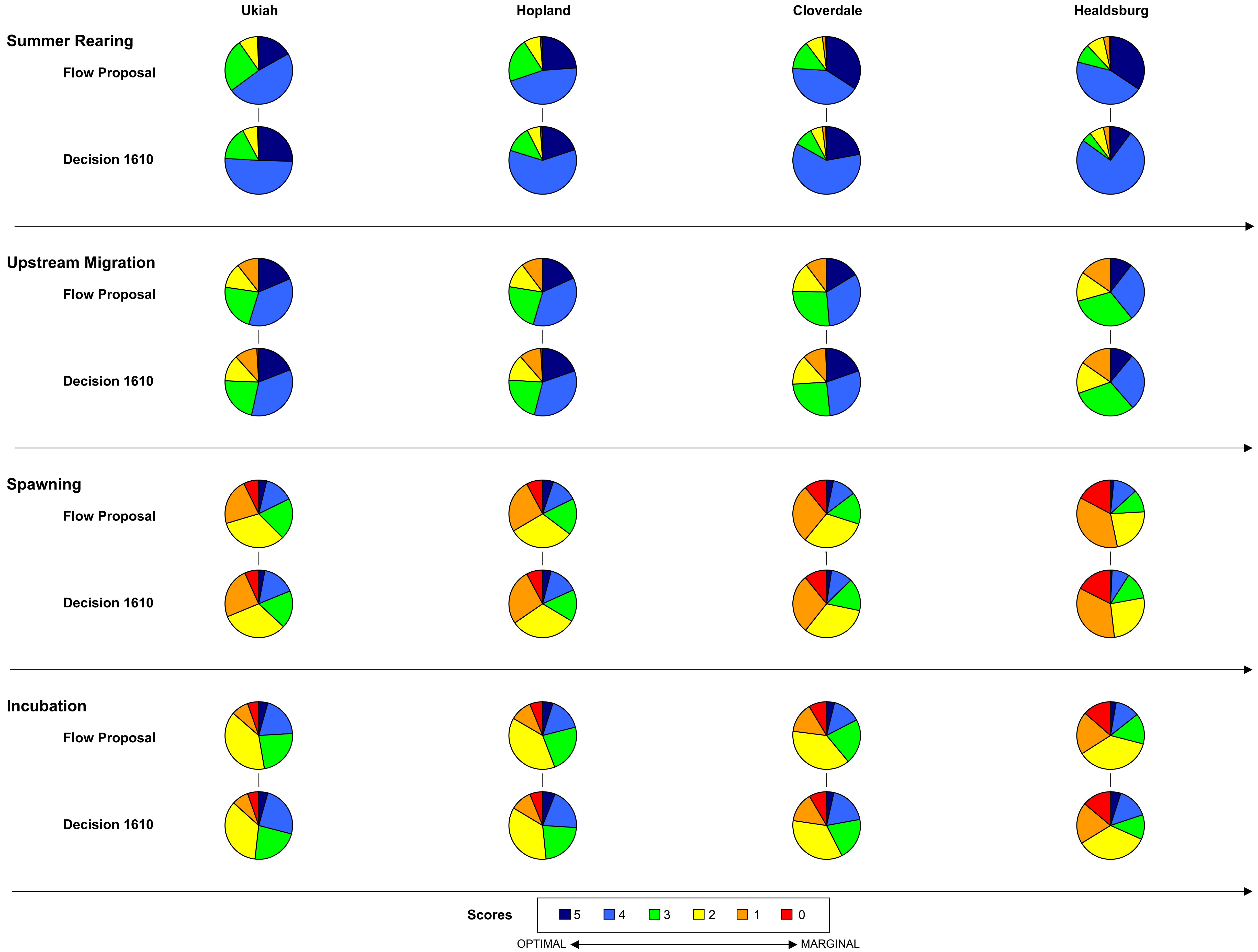


Figure 5-25 Steelhead Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

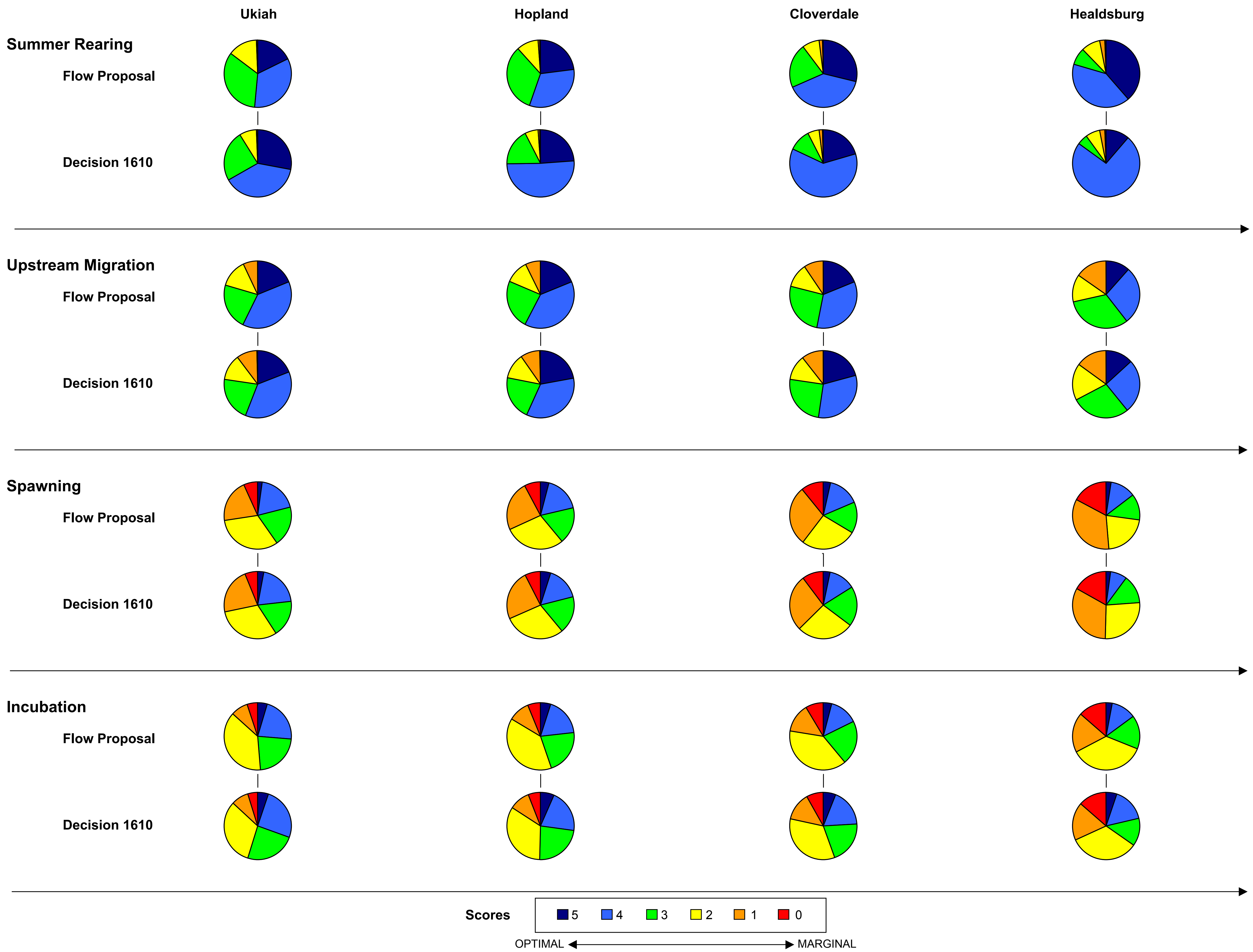


Figure 5-26 Steelhead Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

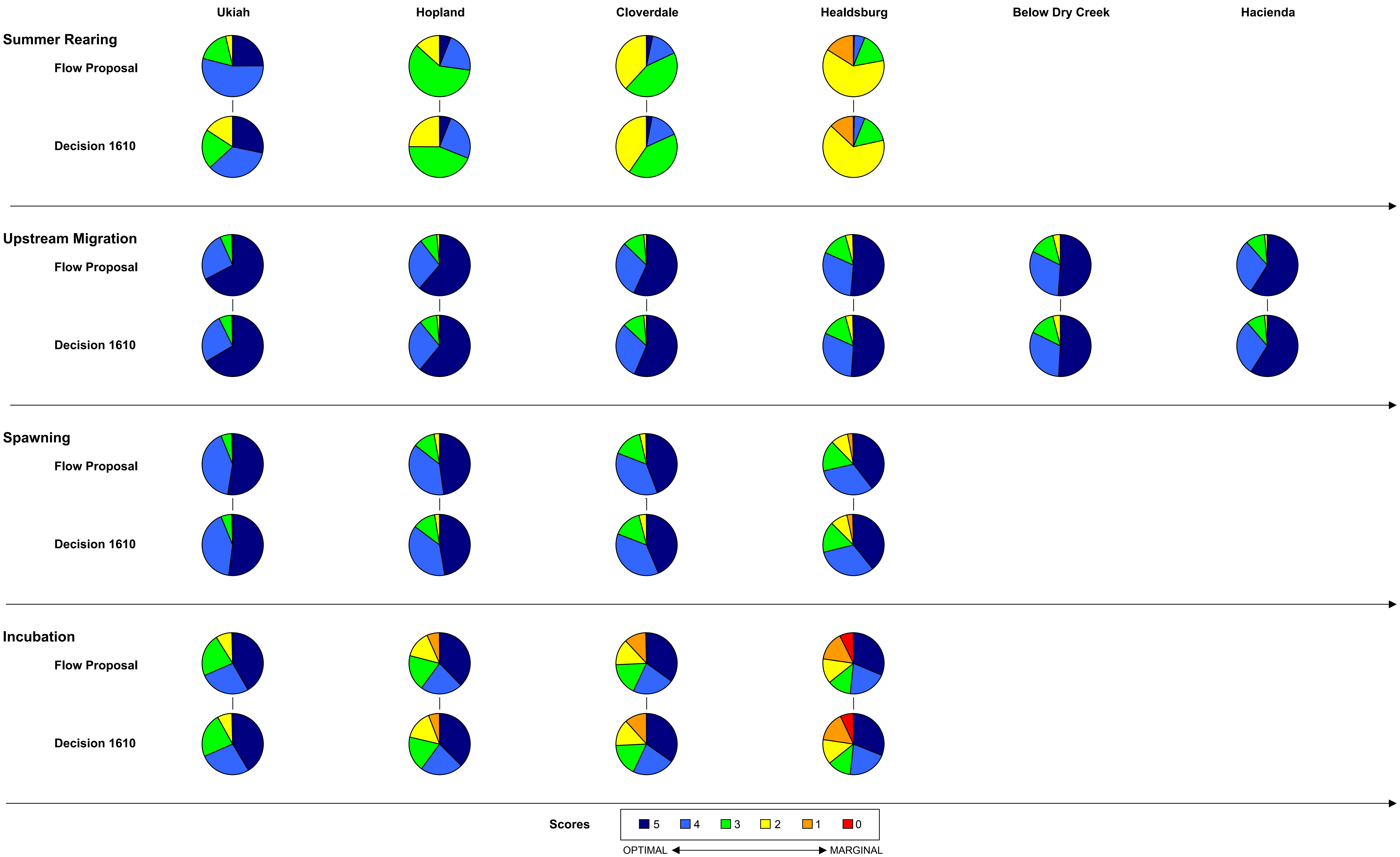


Figure 5-27 Steelhead Temperature Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

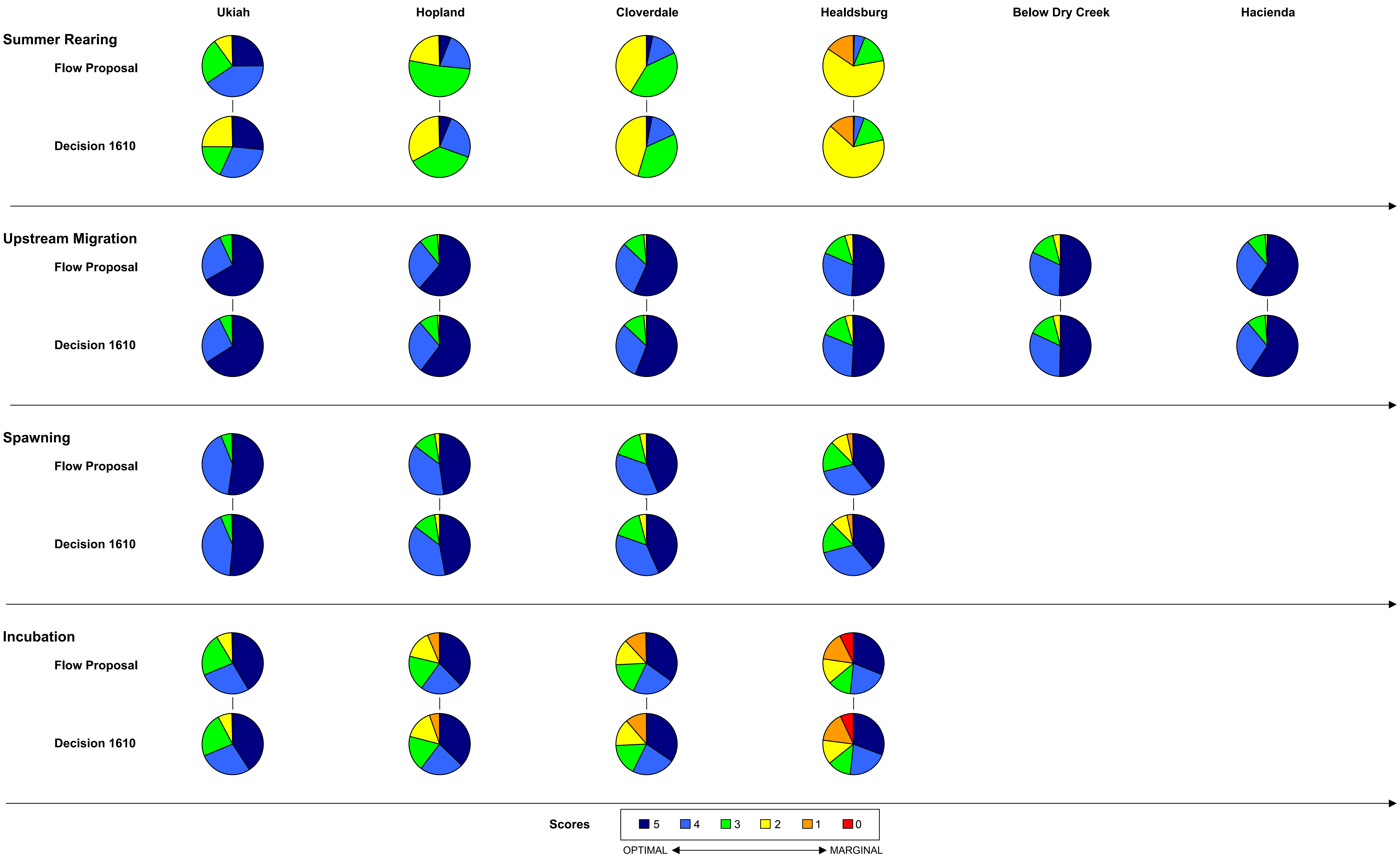


Figure 5-28 Steelhead Temperature Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

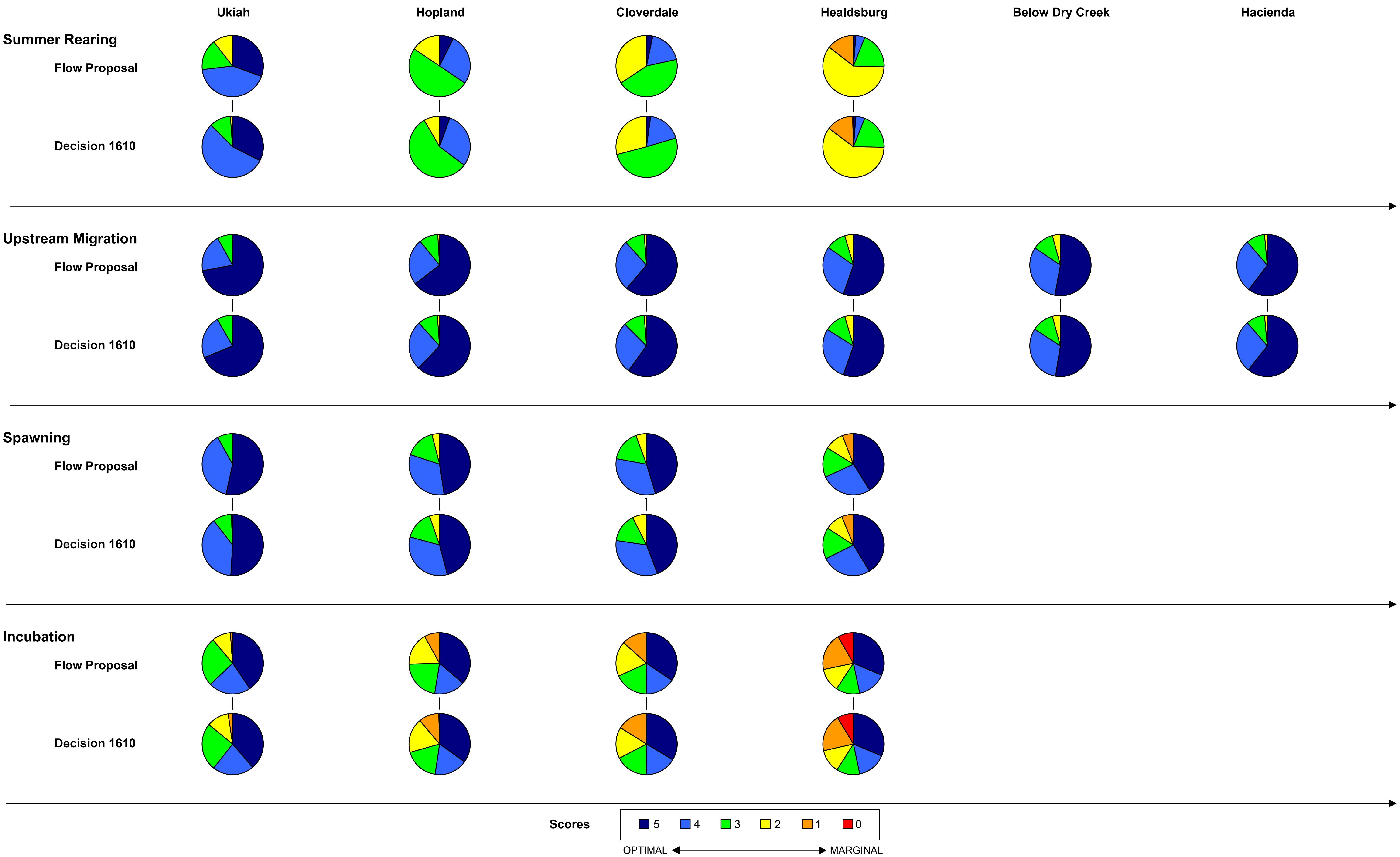


Figure 5-29 Steelhead Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Mainstem Russian River

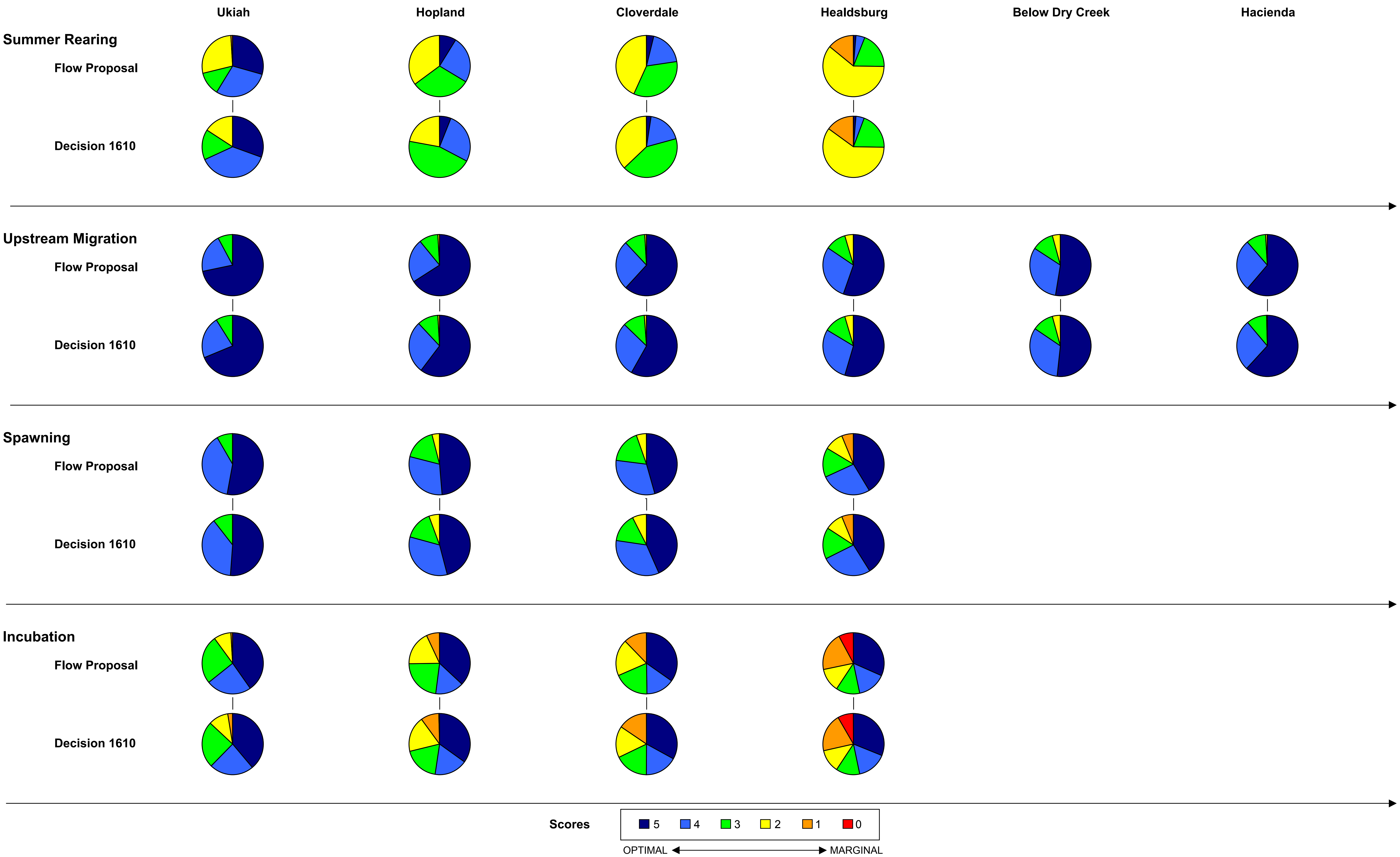


Figure 5-30 Steelhead Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Mainstem Russian River

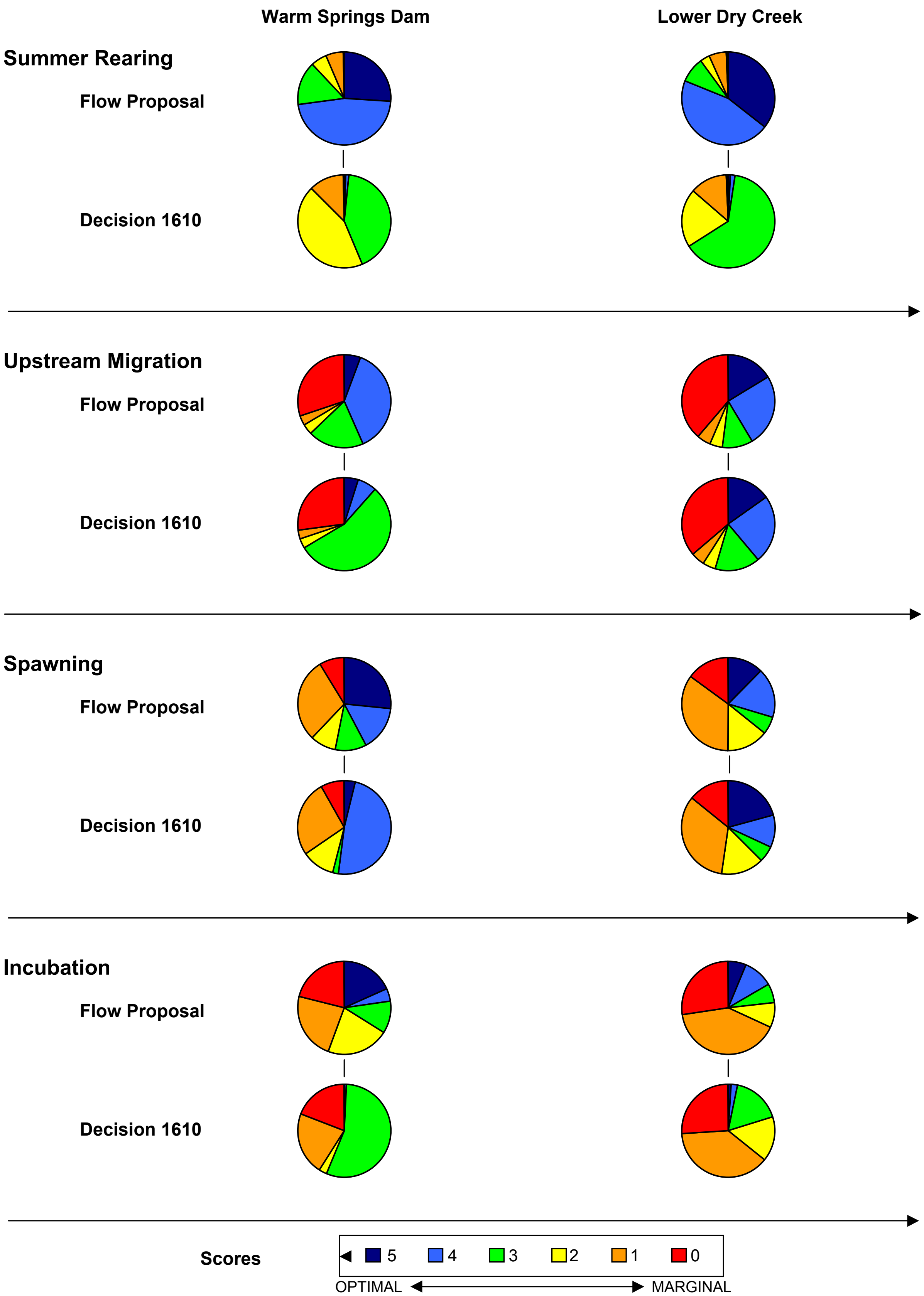


Figure 5-31 Steelhead Flow Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

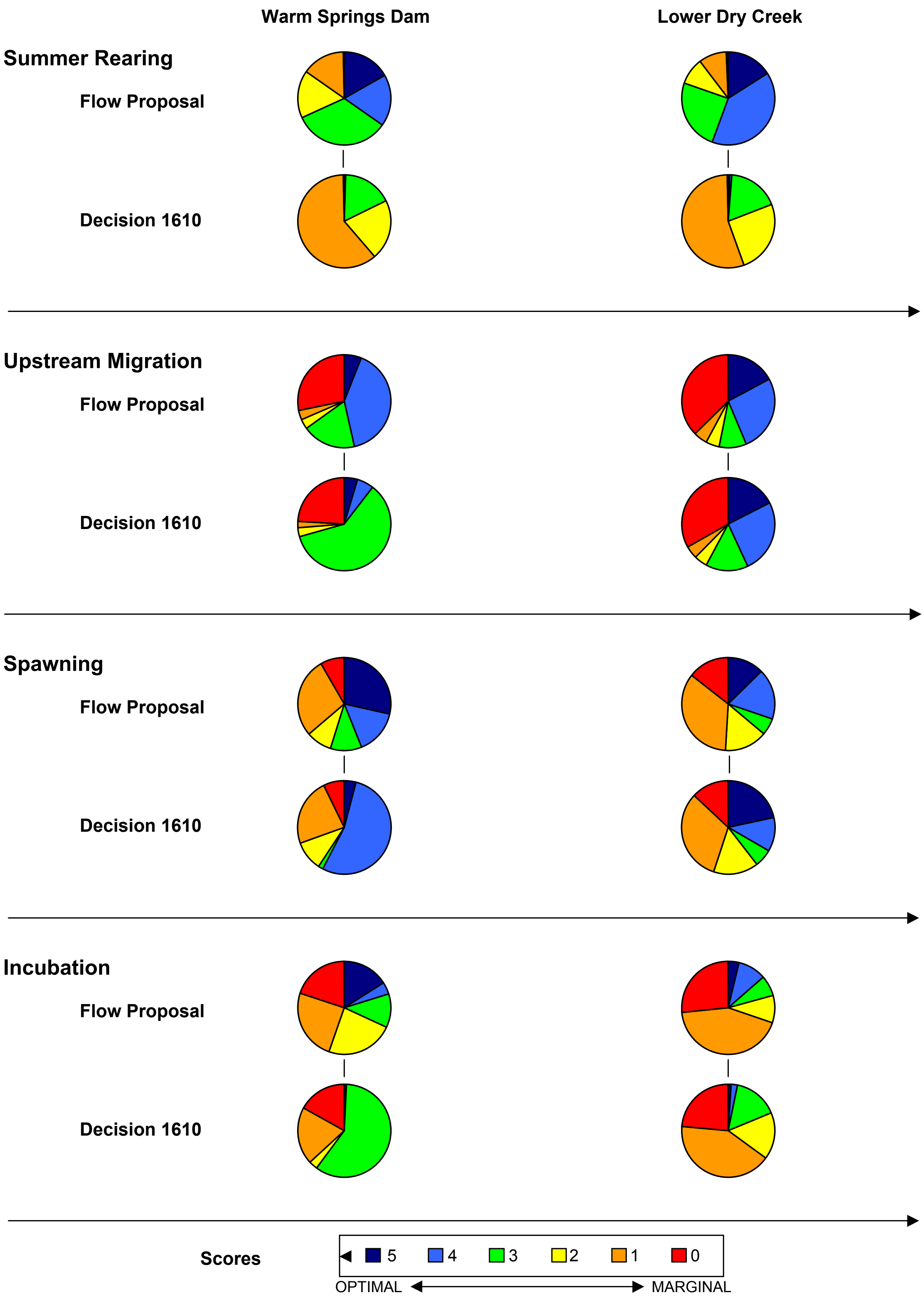


Figure 5-32 Steelhead Flow Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

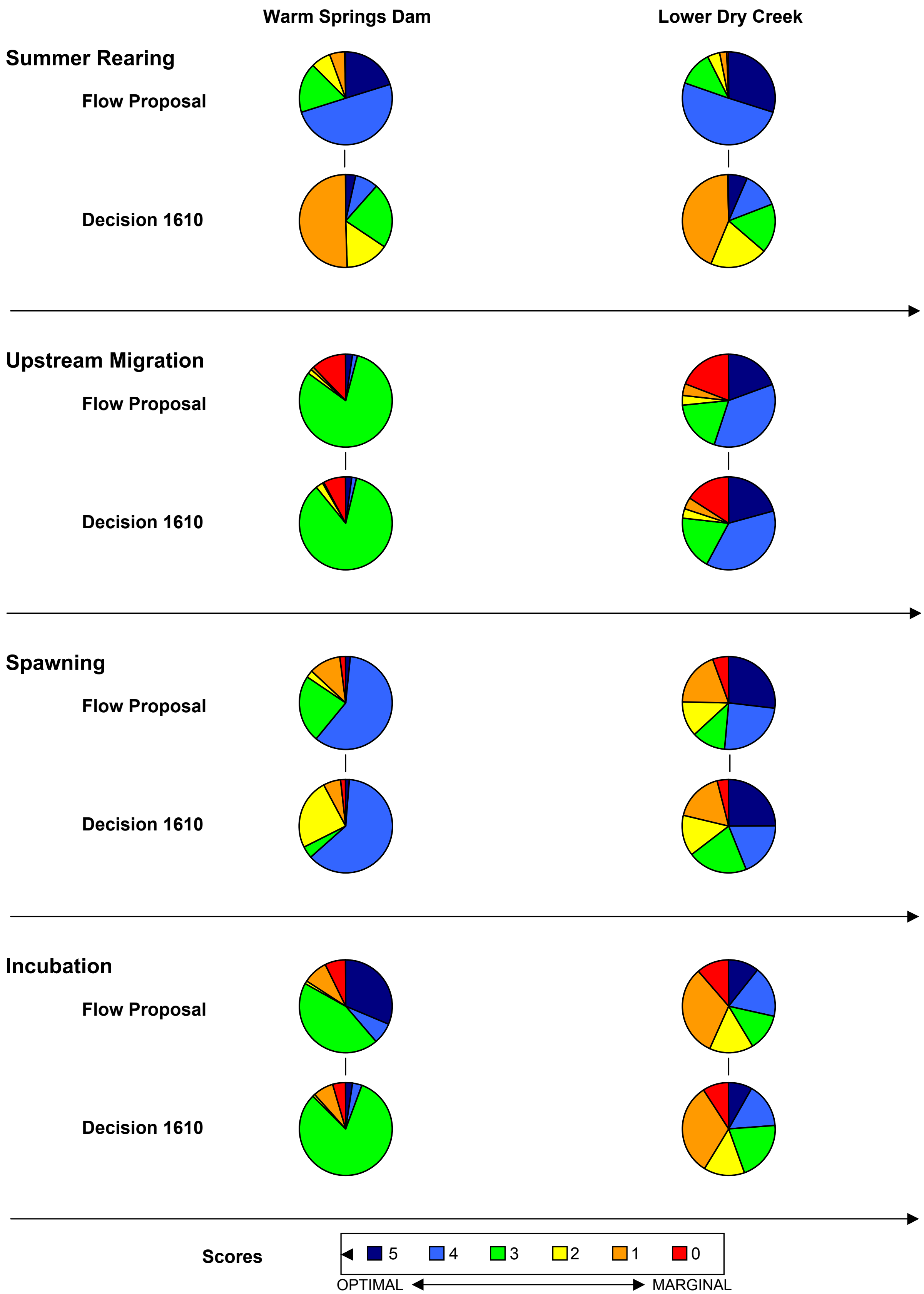


Figure 5-33 Steelhead Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

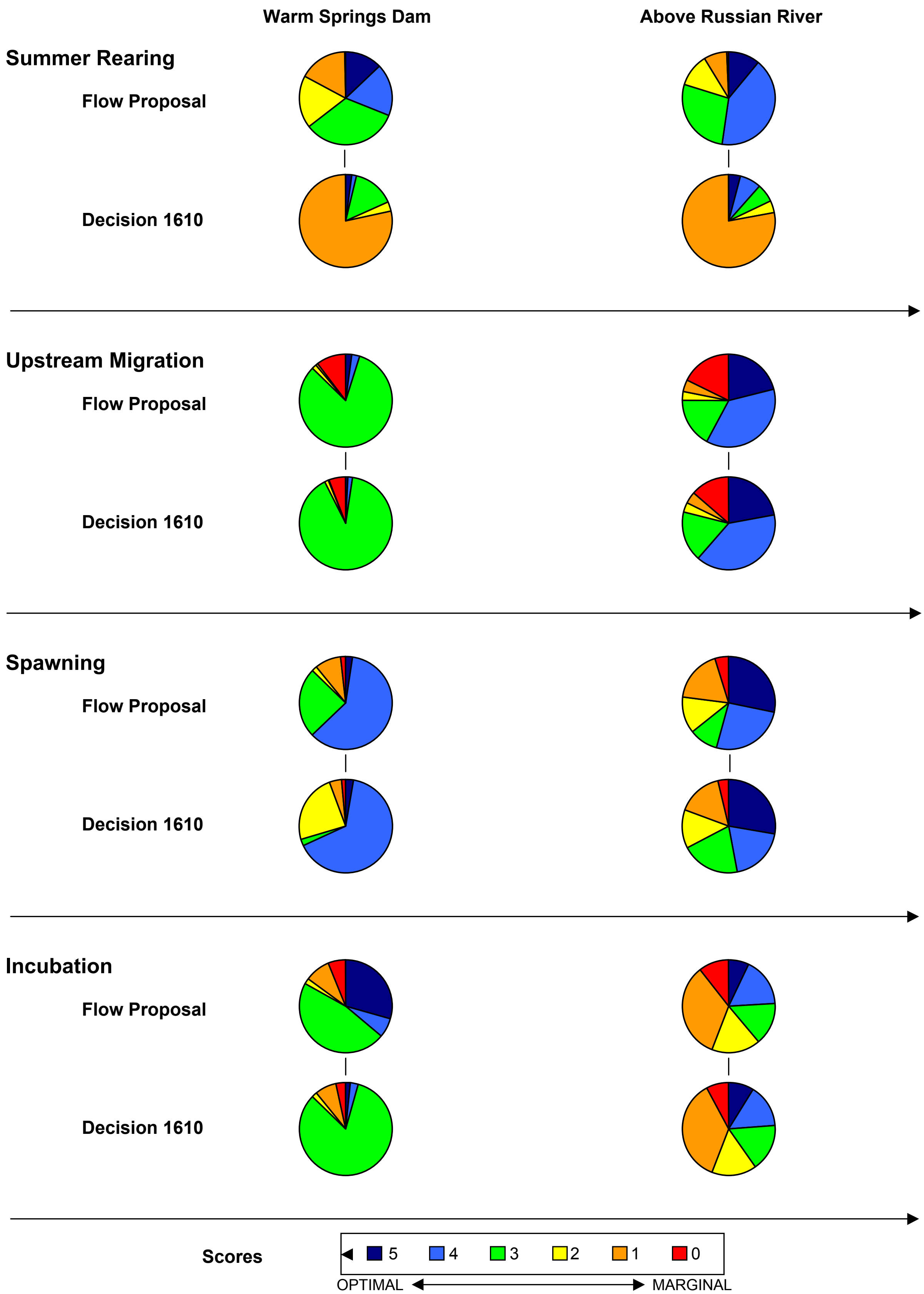


Figure 5-34 Steelhead Flow Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

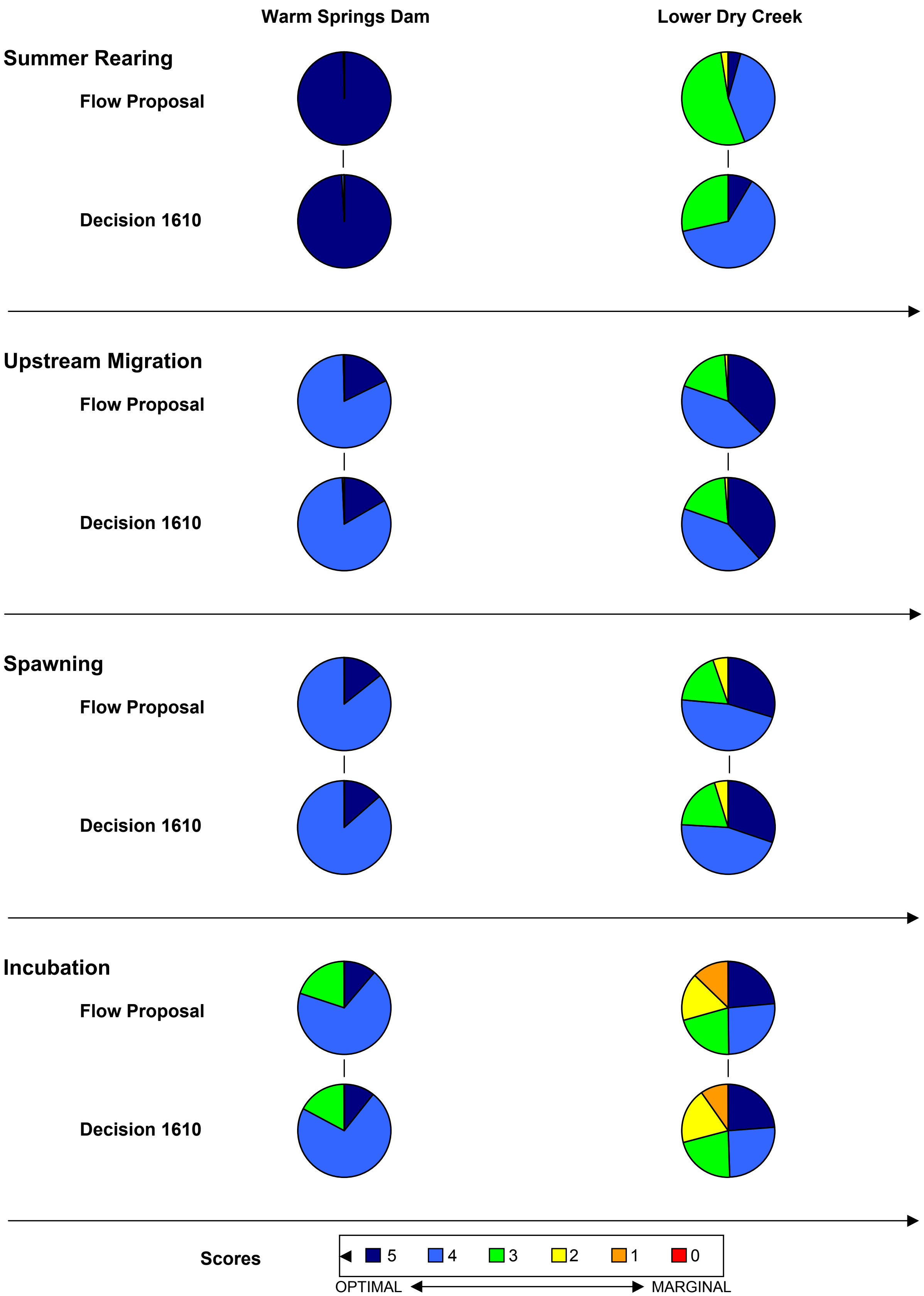


Figure 5-35 Steelhead Temperature Scores - All Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

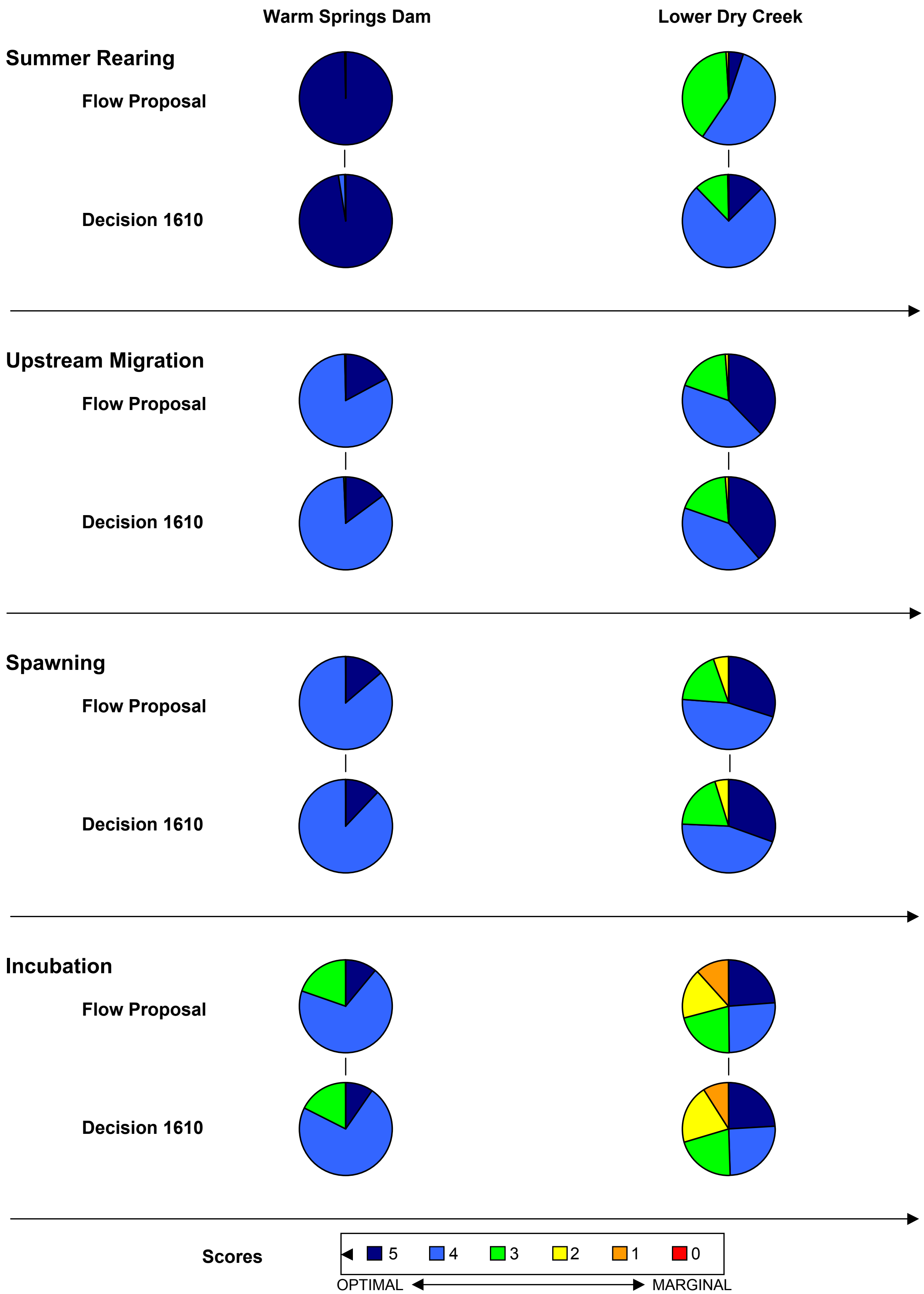


Figure 5-36 Steelhead Temperature Scores - All Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

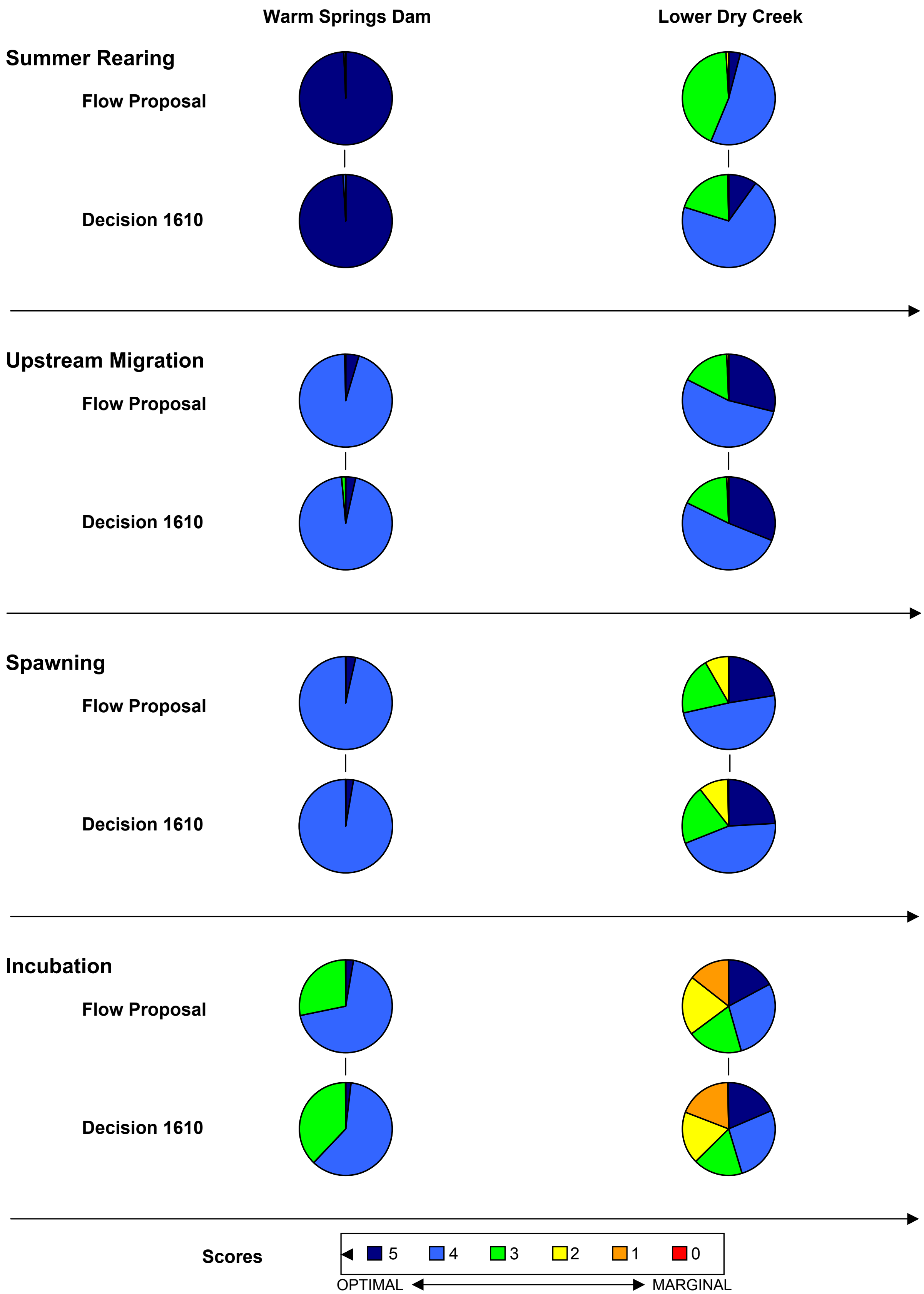


Figure 5-37 Steelhead Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Current Demand in Dry Creek

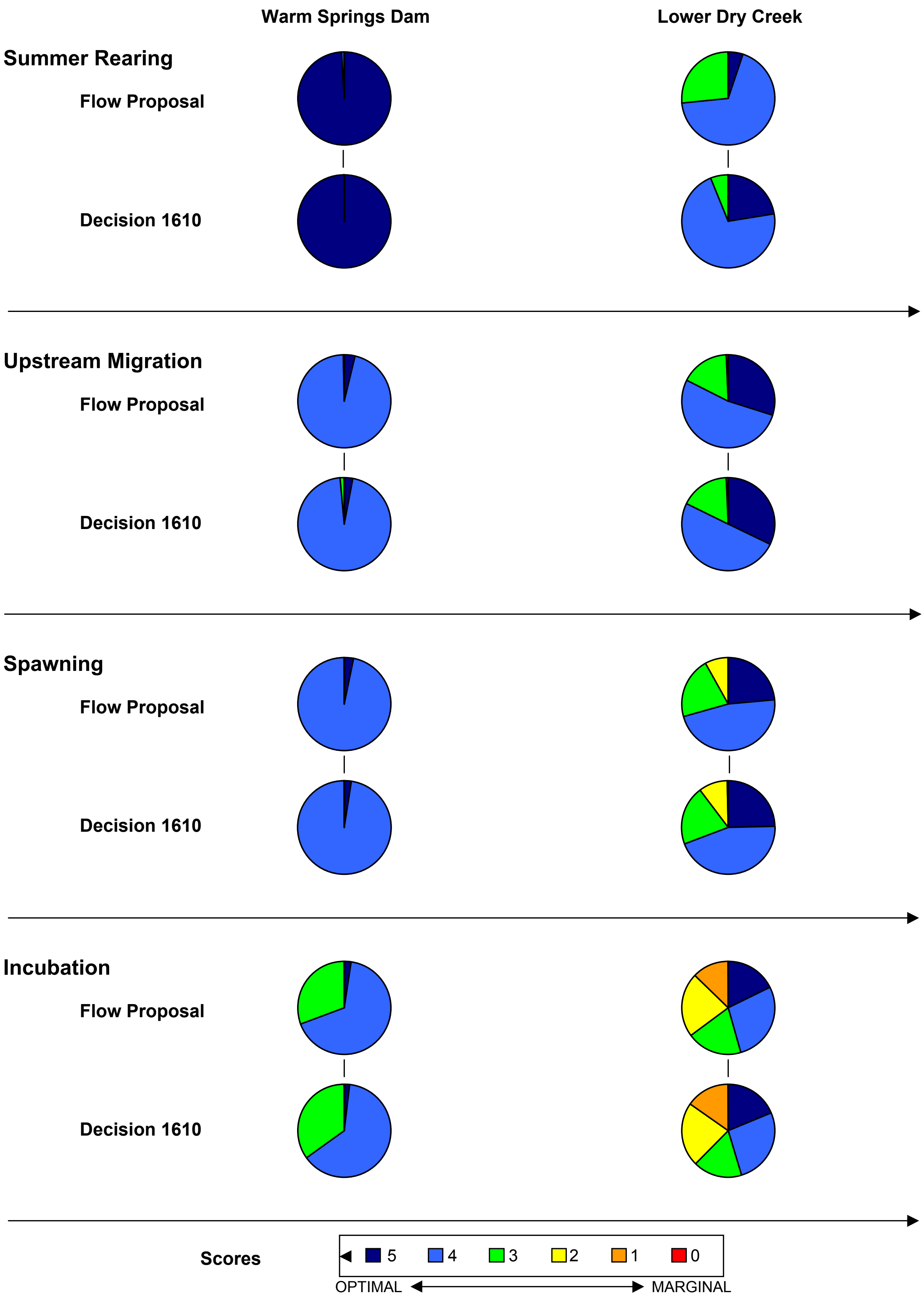


Figure 5-38 Steelhead Temperature Scores - Dry Conditions: D1610 and the Flow Proposal at Buildout Demand in Dry Creek

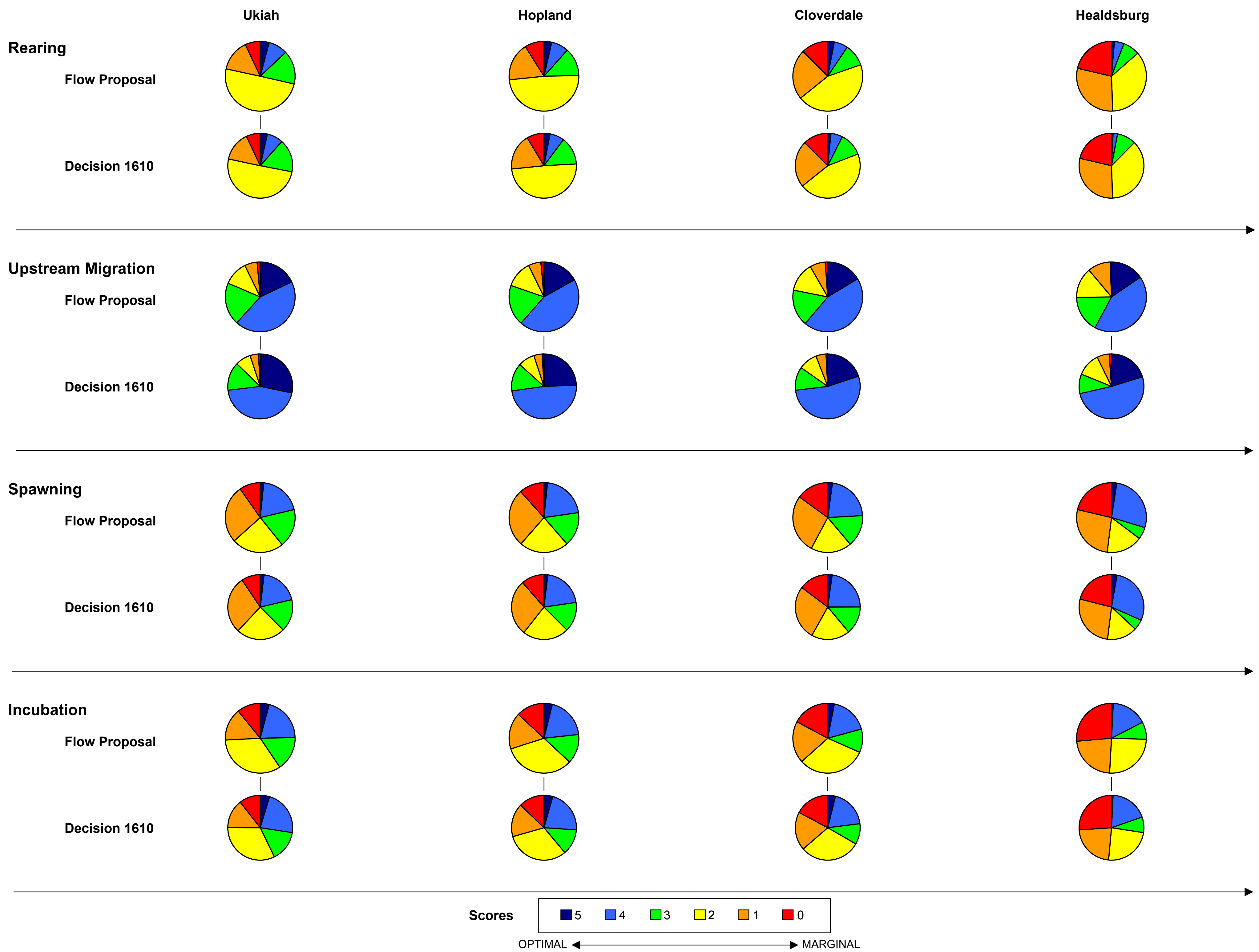


Figure 5-39 Russian River Chinook Salmon Flow Scores for All Water Supply Conditions at Current Demand Levels

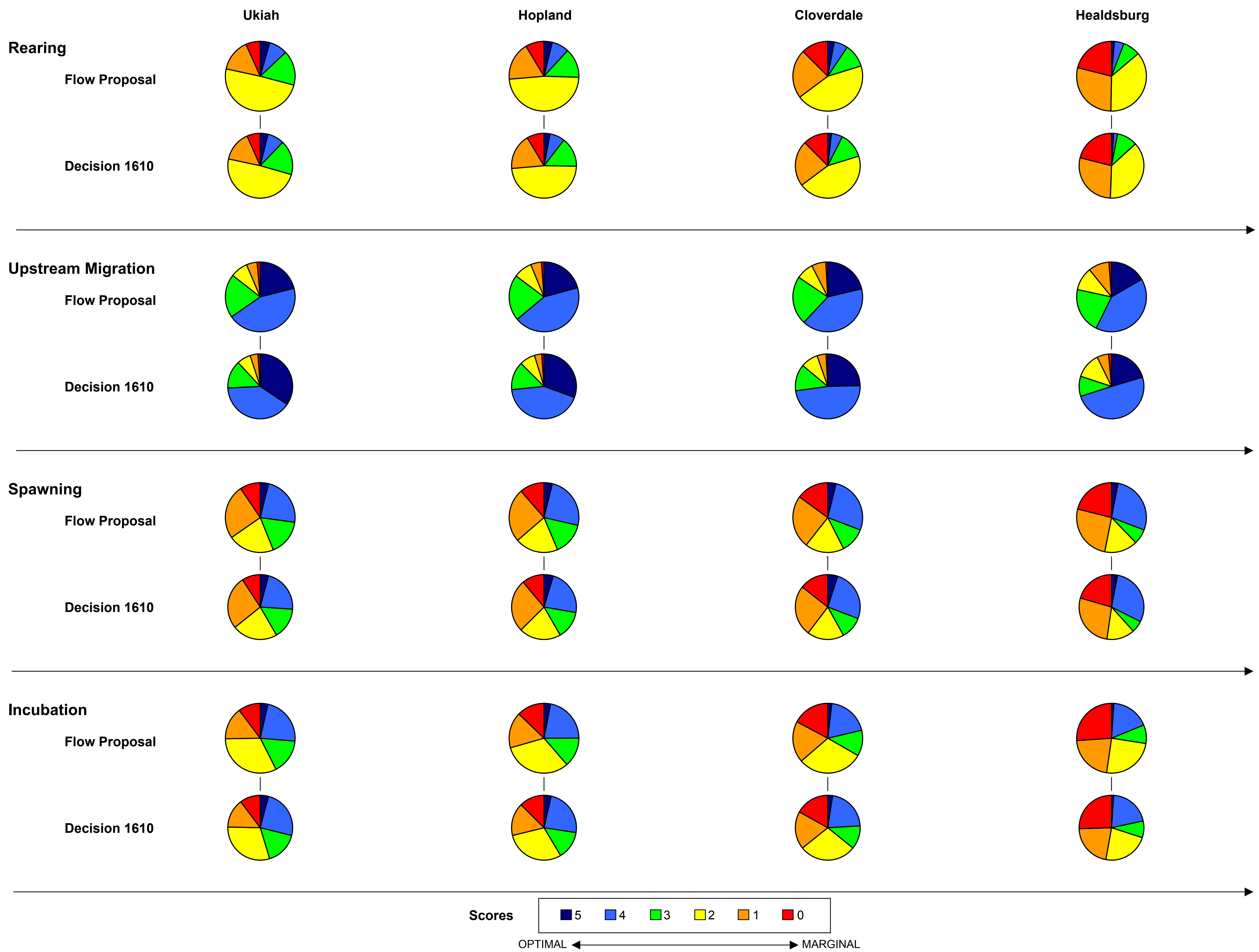


Figure 5-40 Russian River Chinook Salmon Flow Scores for All Water Supply Conditions at Buildout Demand Levels

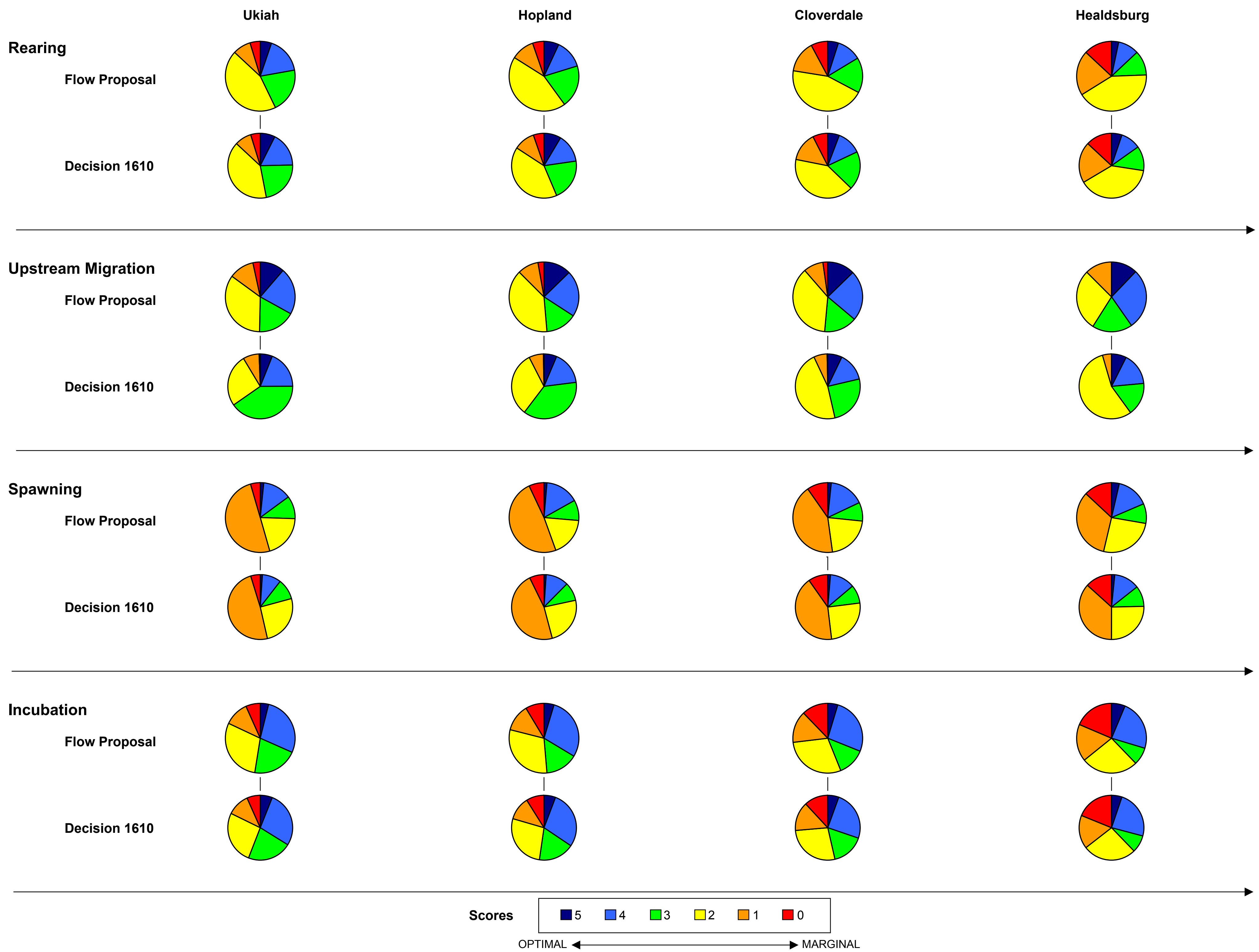


Figure 5-41 Russian River Chinook Salmon Flow Scores for Dry Water Supply Conditions at Current Demand Levels

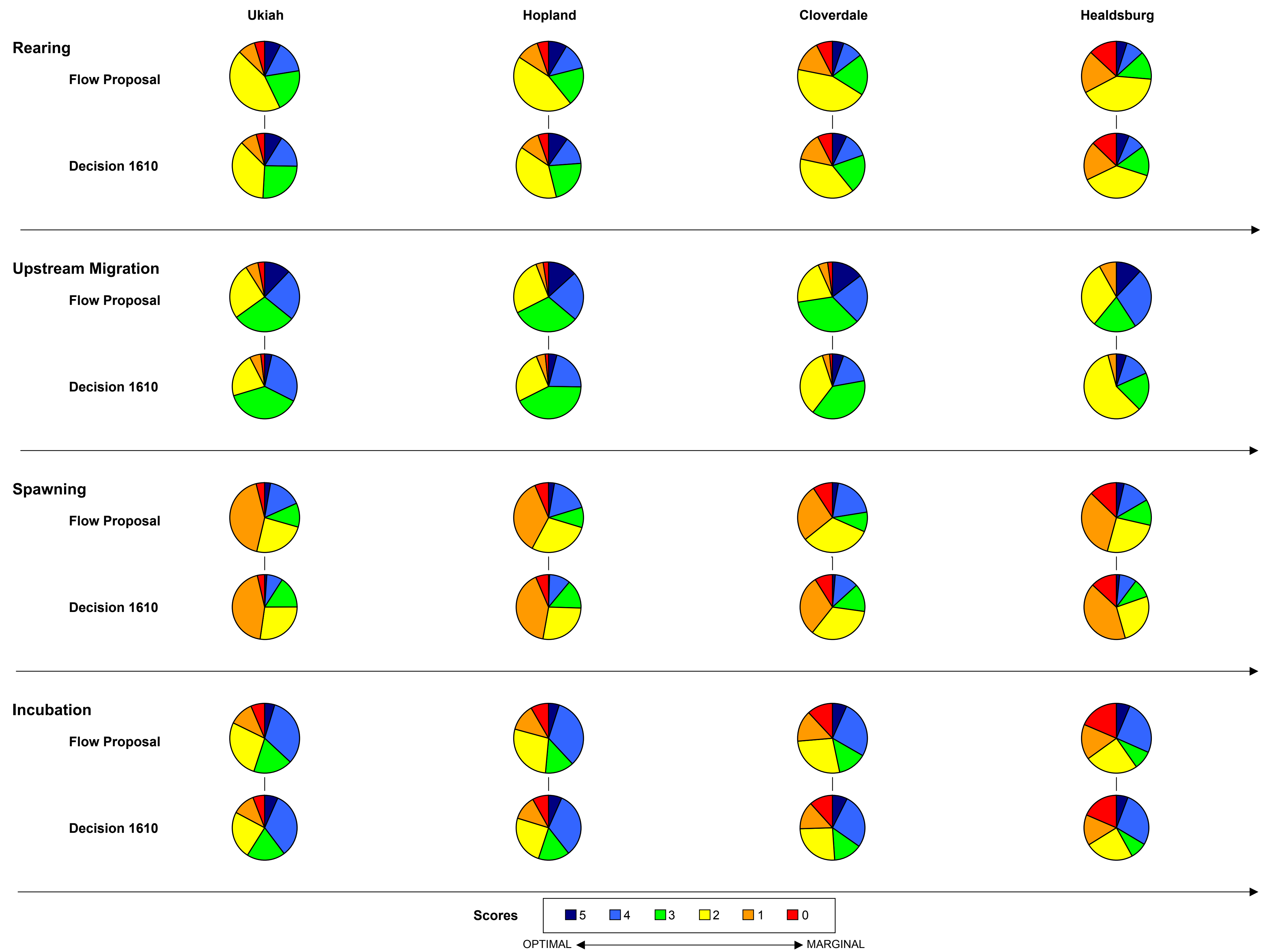


Figure 5-42 Russian River Chinook Salmon Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

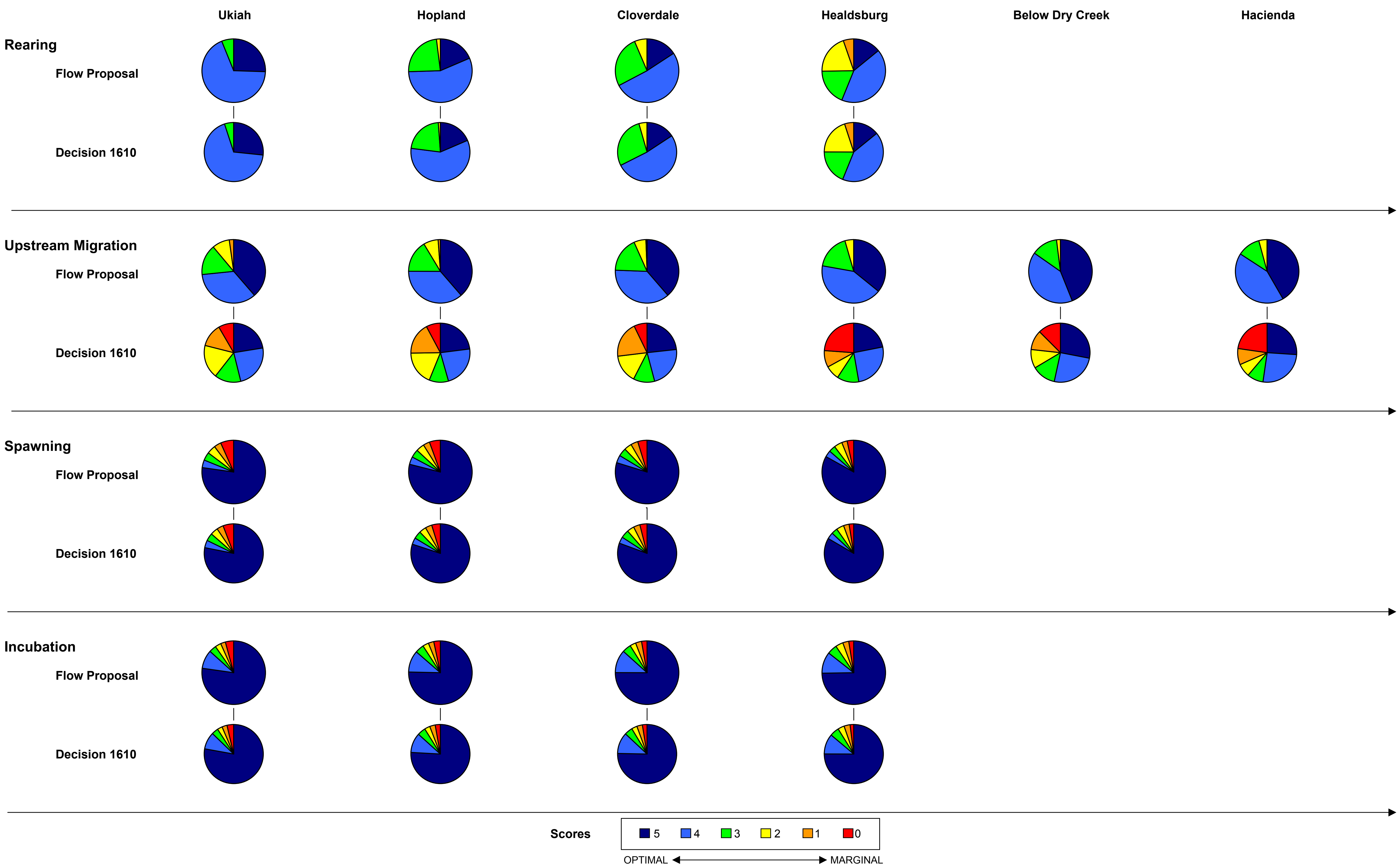


Figure 5-43 Russian River Chinook Salmon Temperature Scores for All Water Supply Conditions at Current Demand Levels

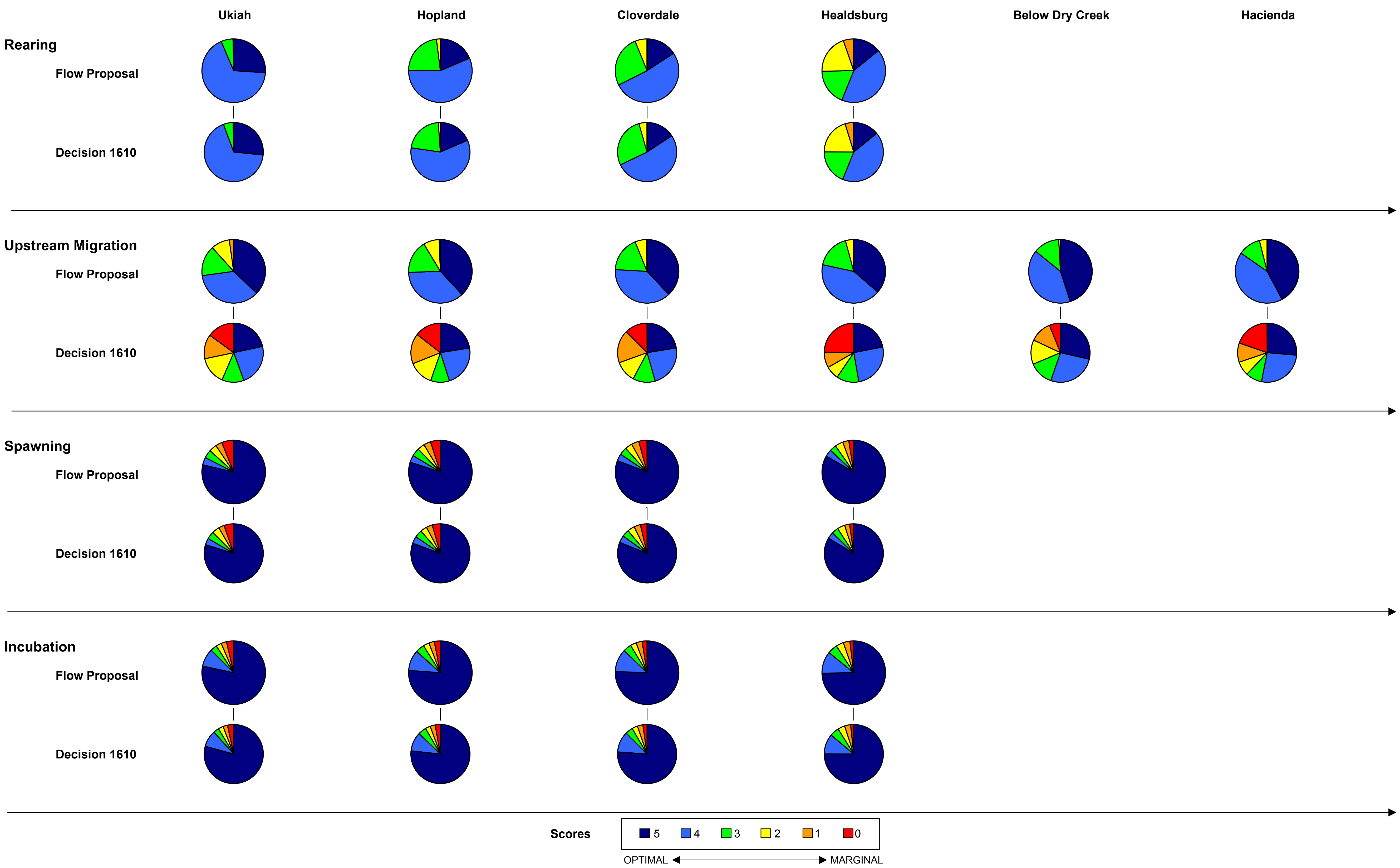


Figure 5-44 Russian River Chinook Salmon Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

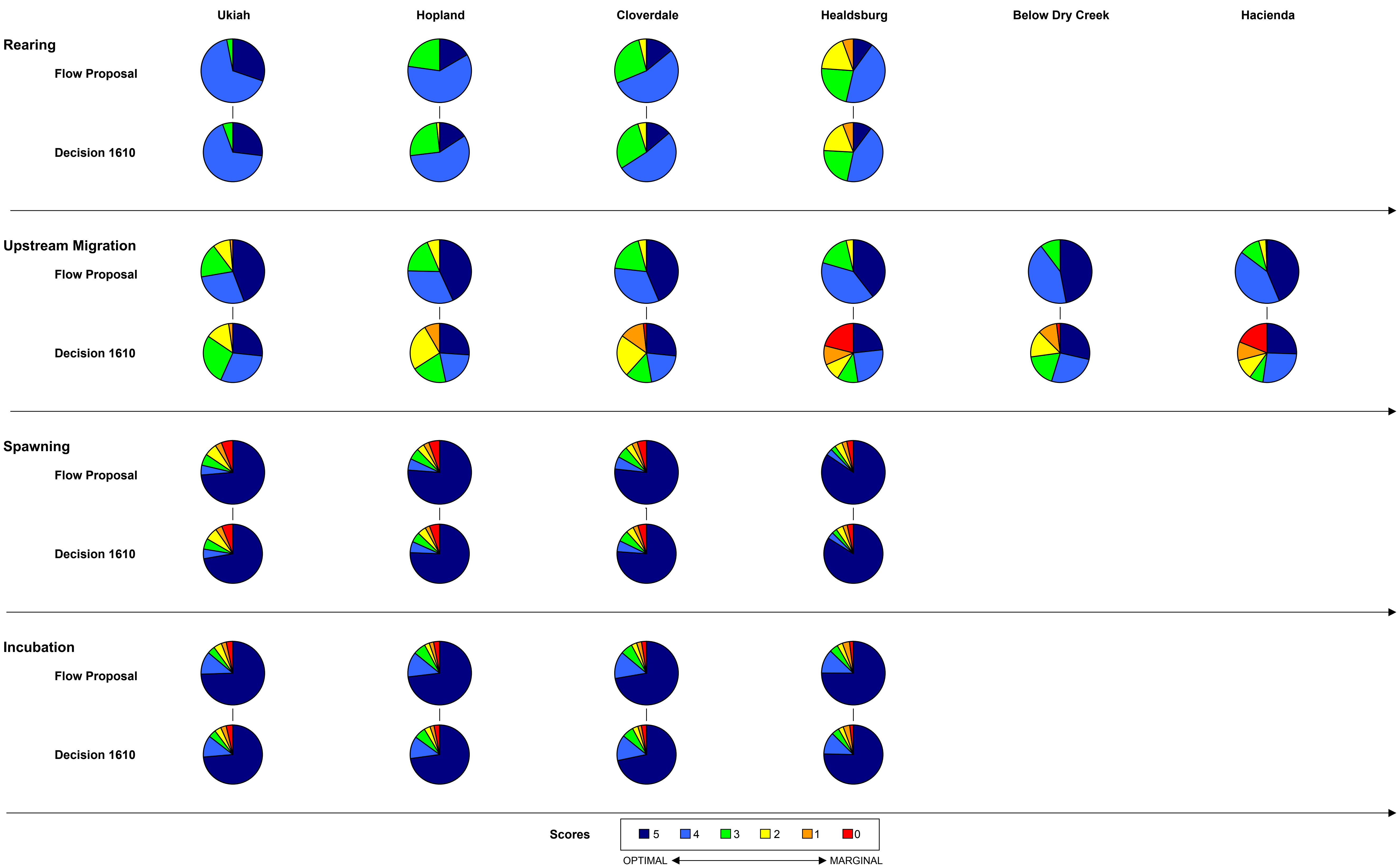


Figure 5-45 Russian River Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

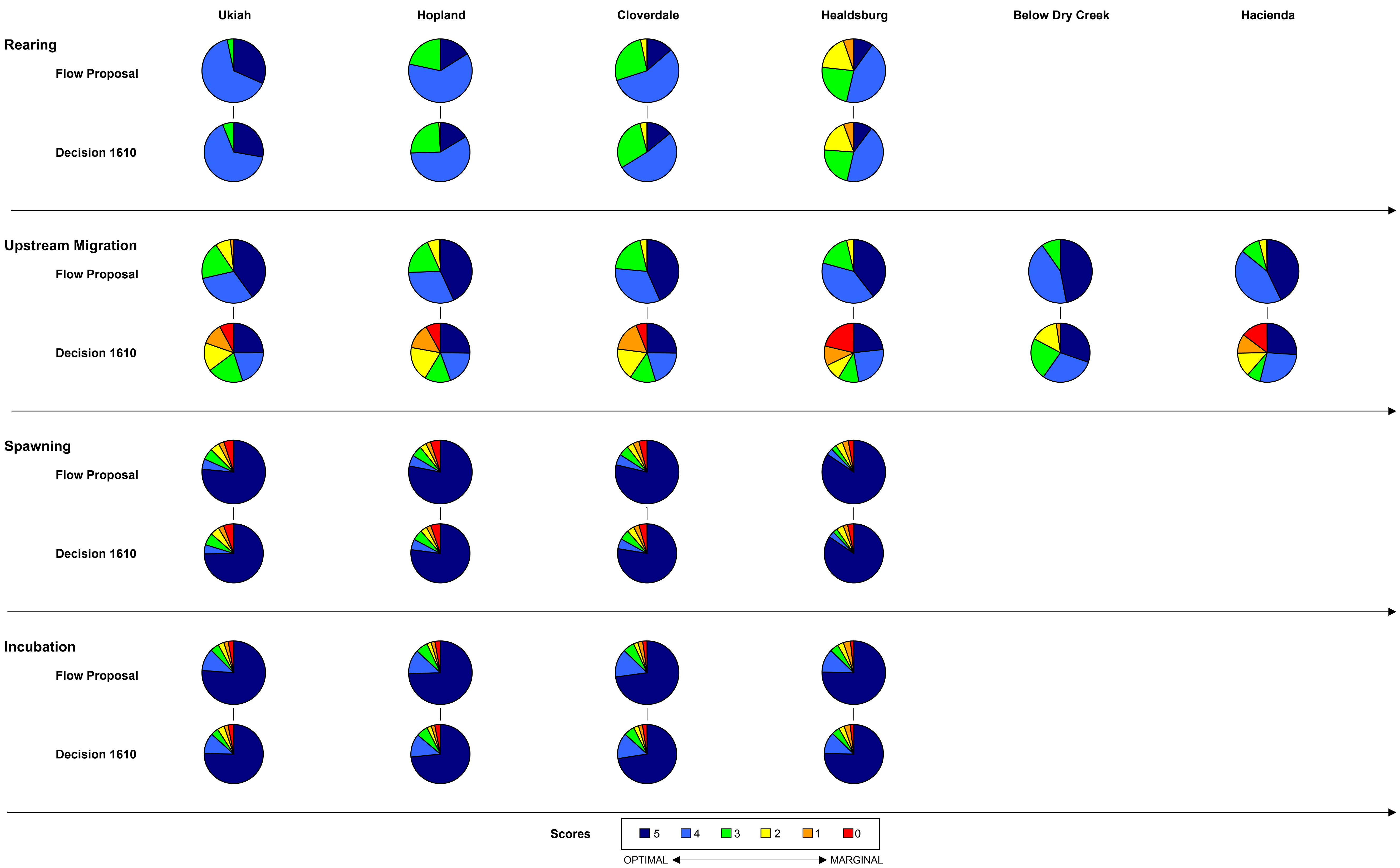


Figure 5-46 Russian River Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

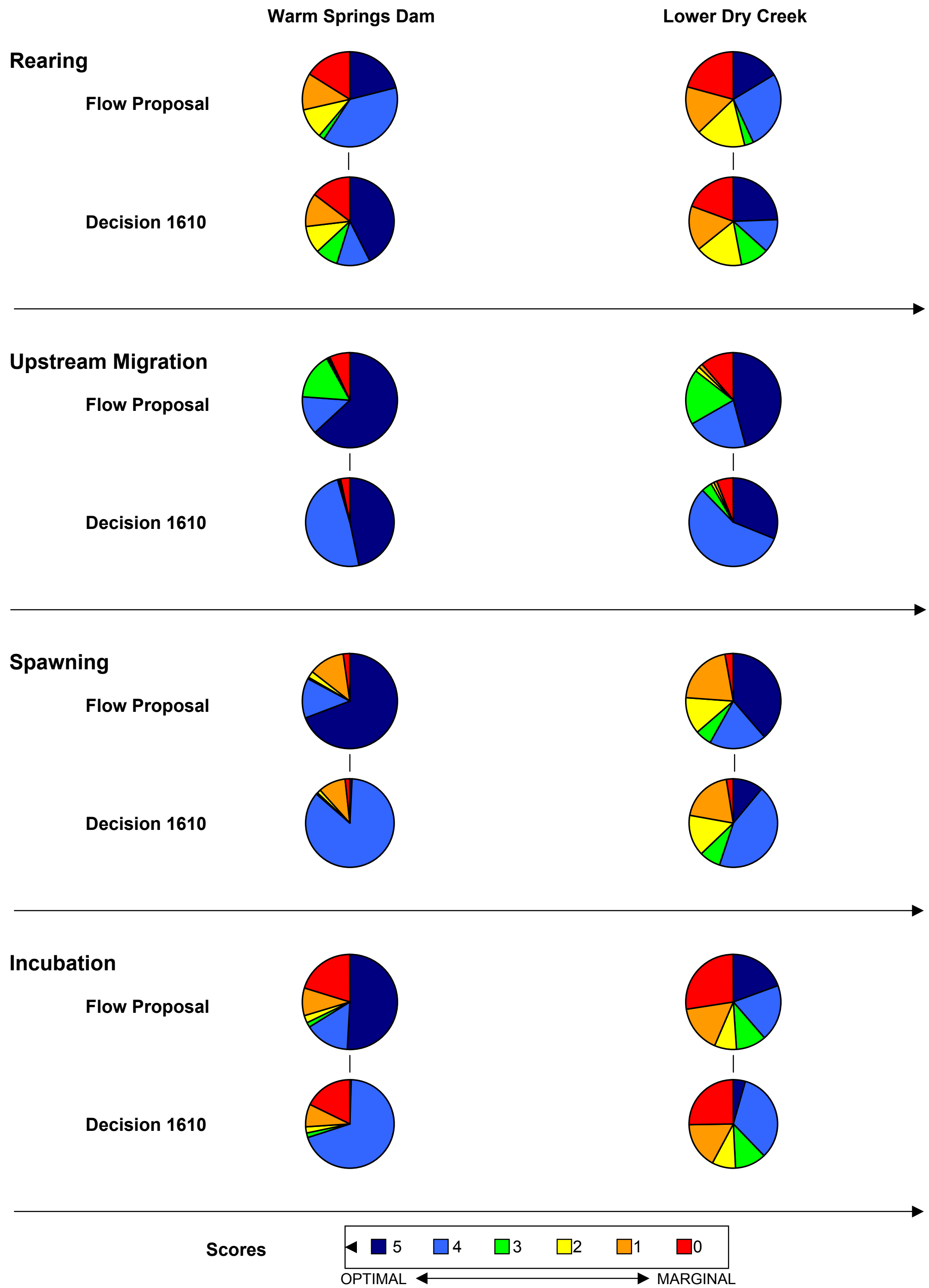


Figure 5-47 Dry Creek Chinook Salmon Flow Scores for All Water Supply Conditions at Current Demand Levels

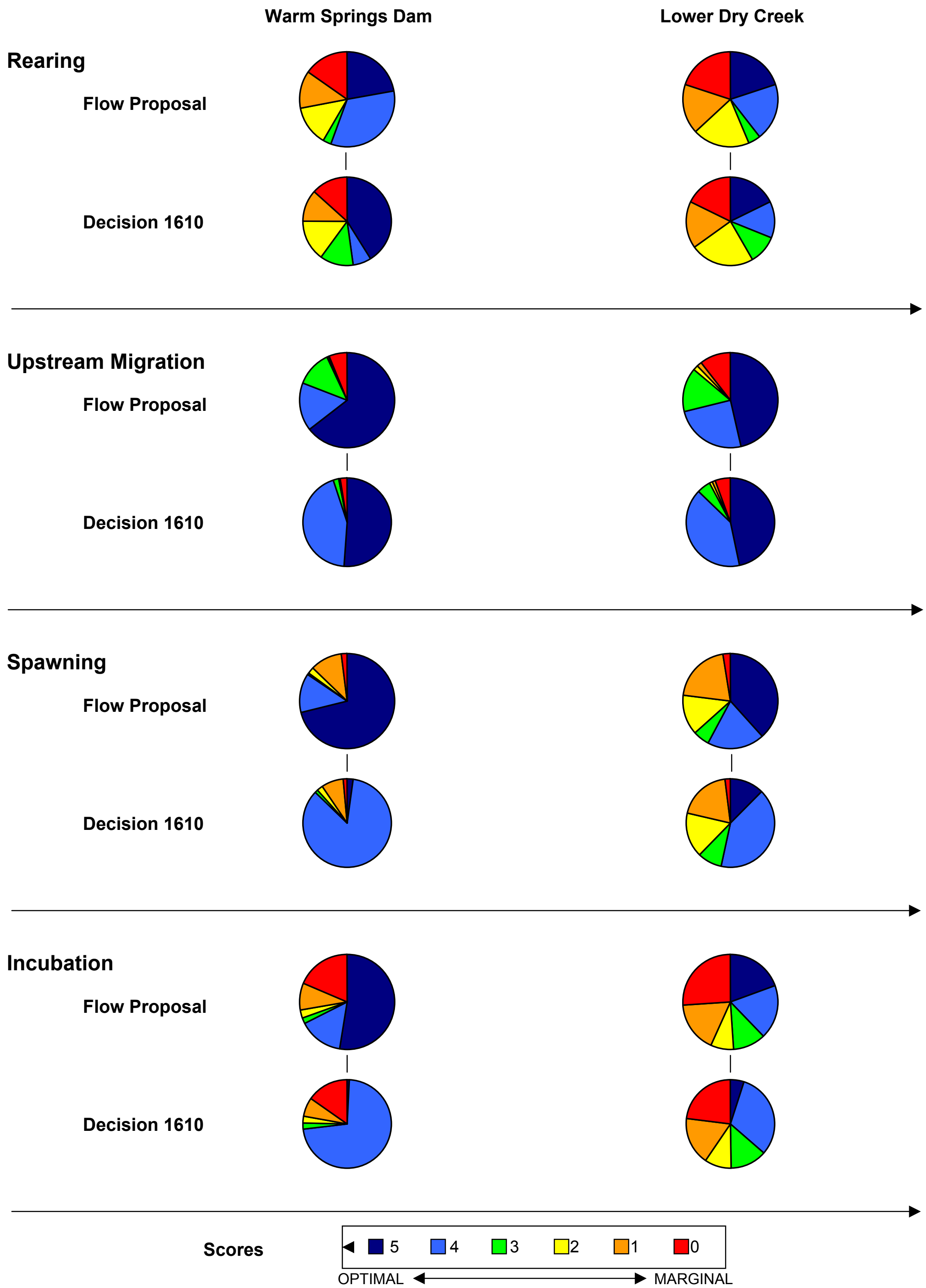


Figure 5-48 Dry Creek Chinook Salmon Flow Scores for All Water Supply Conditions at Buildout Demand Levels

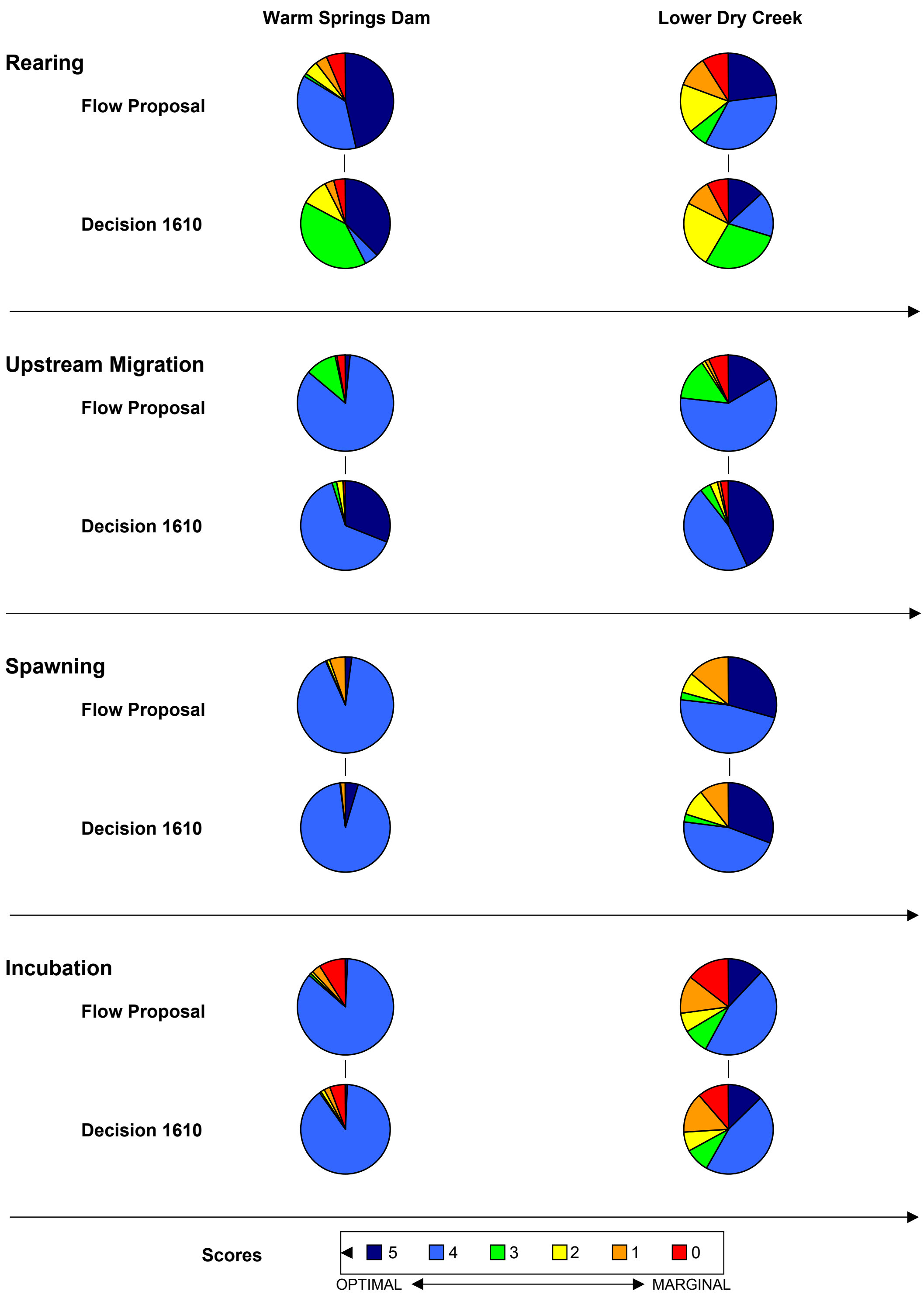


Figure 5-49 Dry Creek Chinook Salmon Flow Scores for Dry Water Supply Conditions at Current Demand Levels

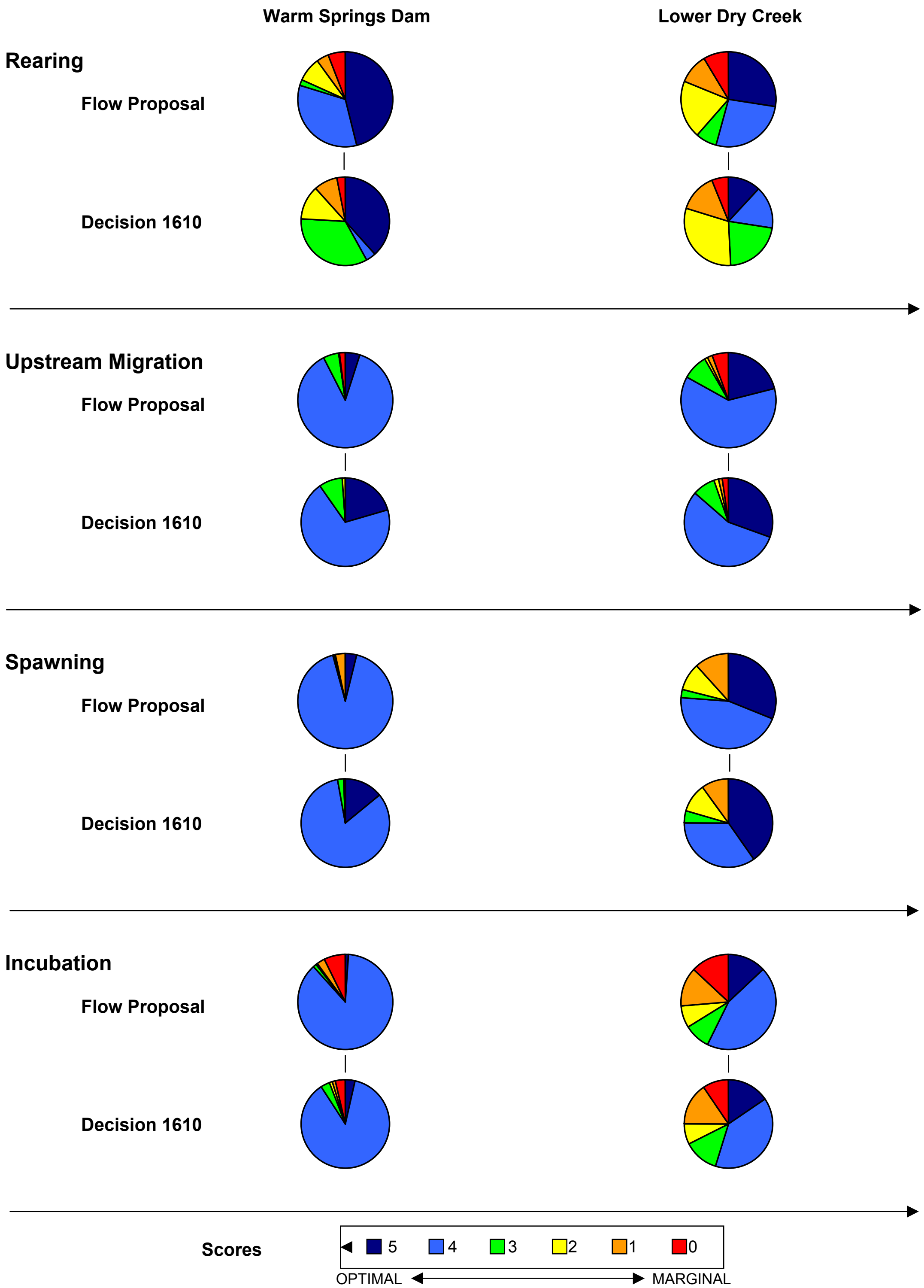


Figure 5-50 Dry Creek Chinook Salmon Flow Scores for Dry Water Supply Conditions at Buildout Demand Levels

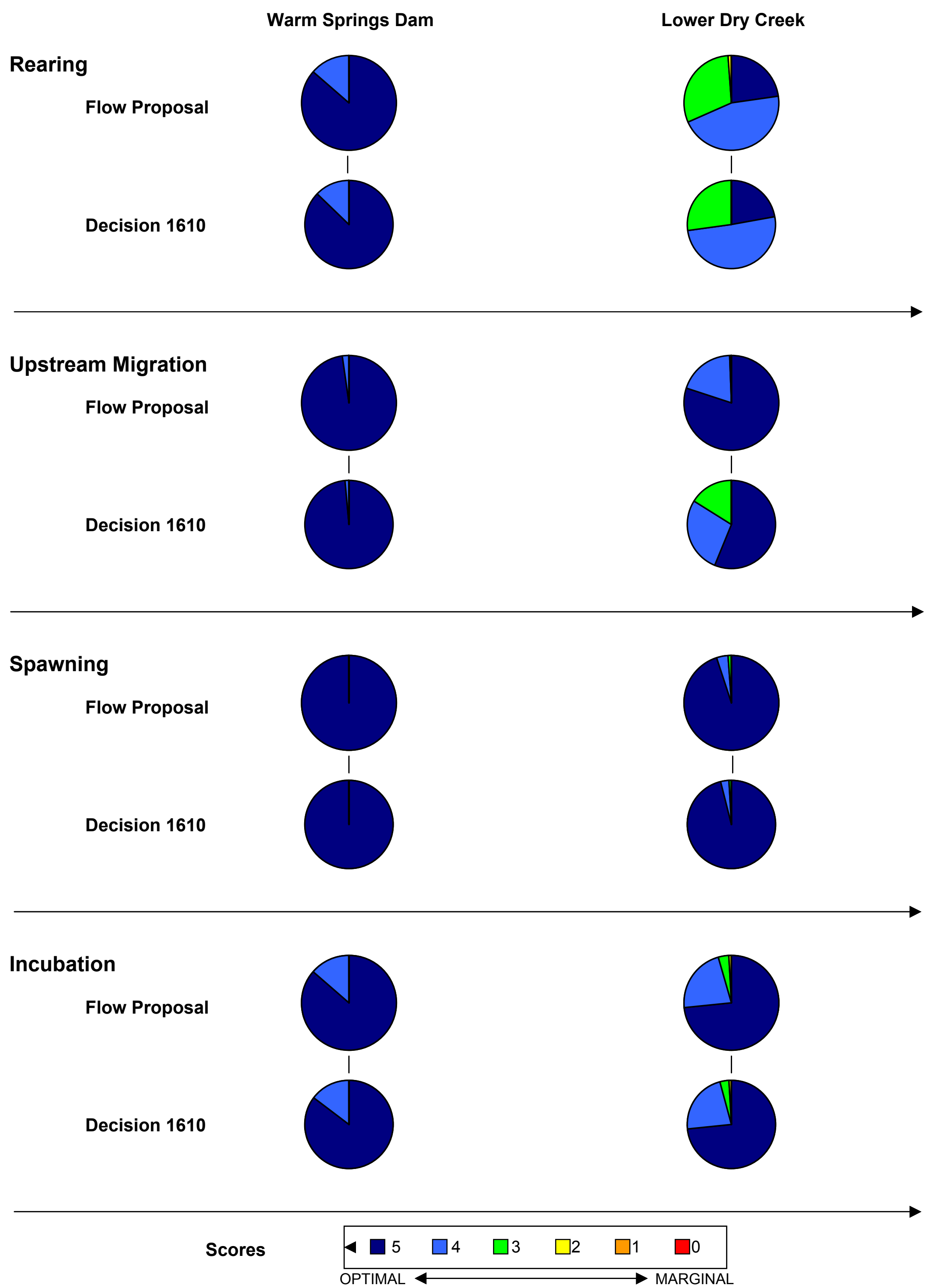


Figure 5-51 Dry Creek Chinook Salmon Temperature Scores for All Water Supply Conditions at Current Demand Levels

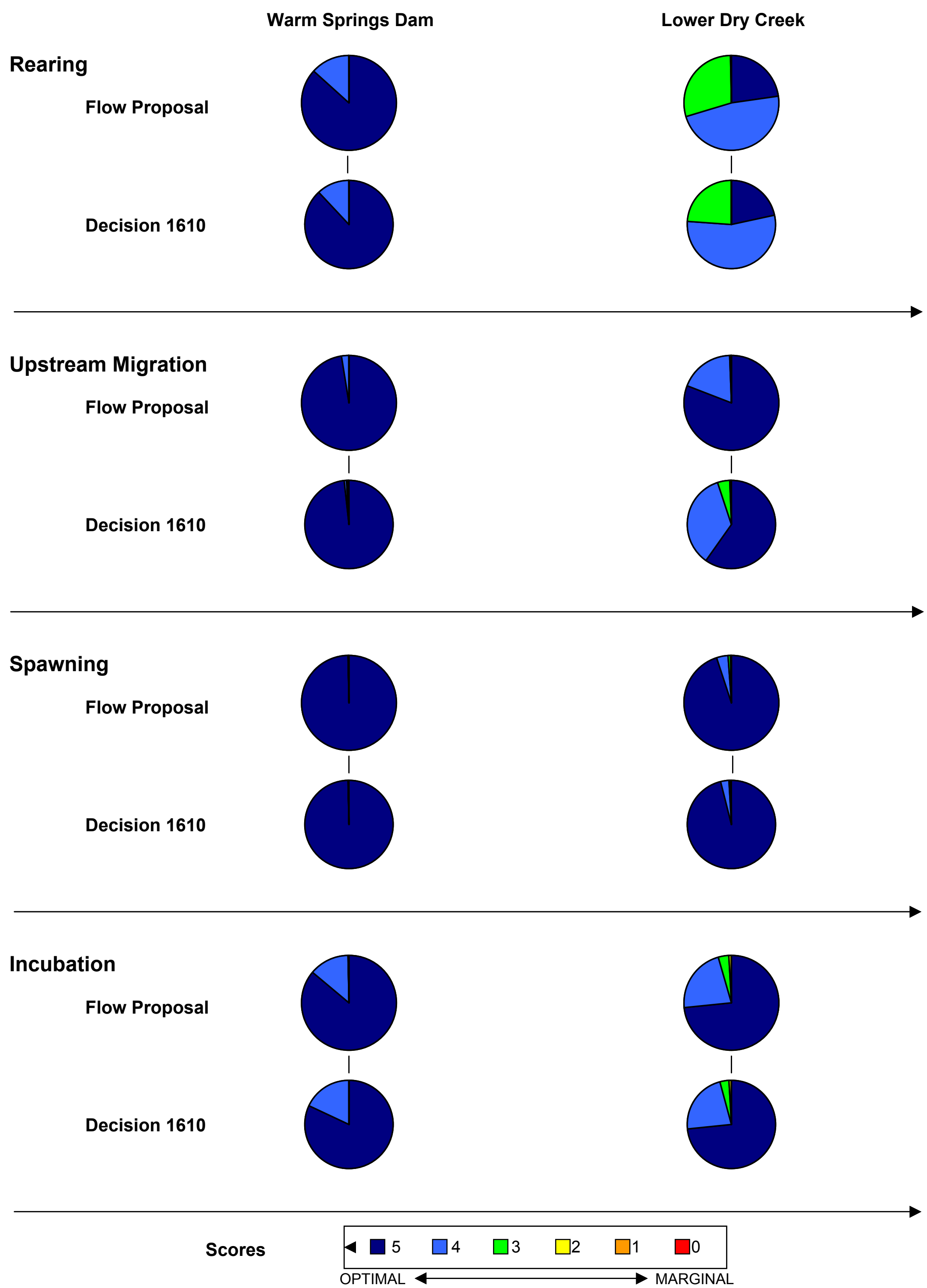


Figure 5-52 Dry Creek Chinook Salmon Temperature Scores for All Water Supply Conditions at Buildout Demand Levels

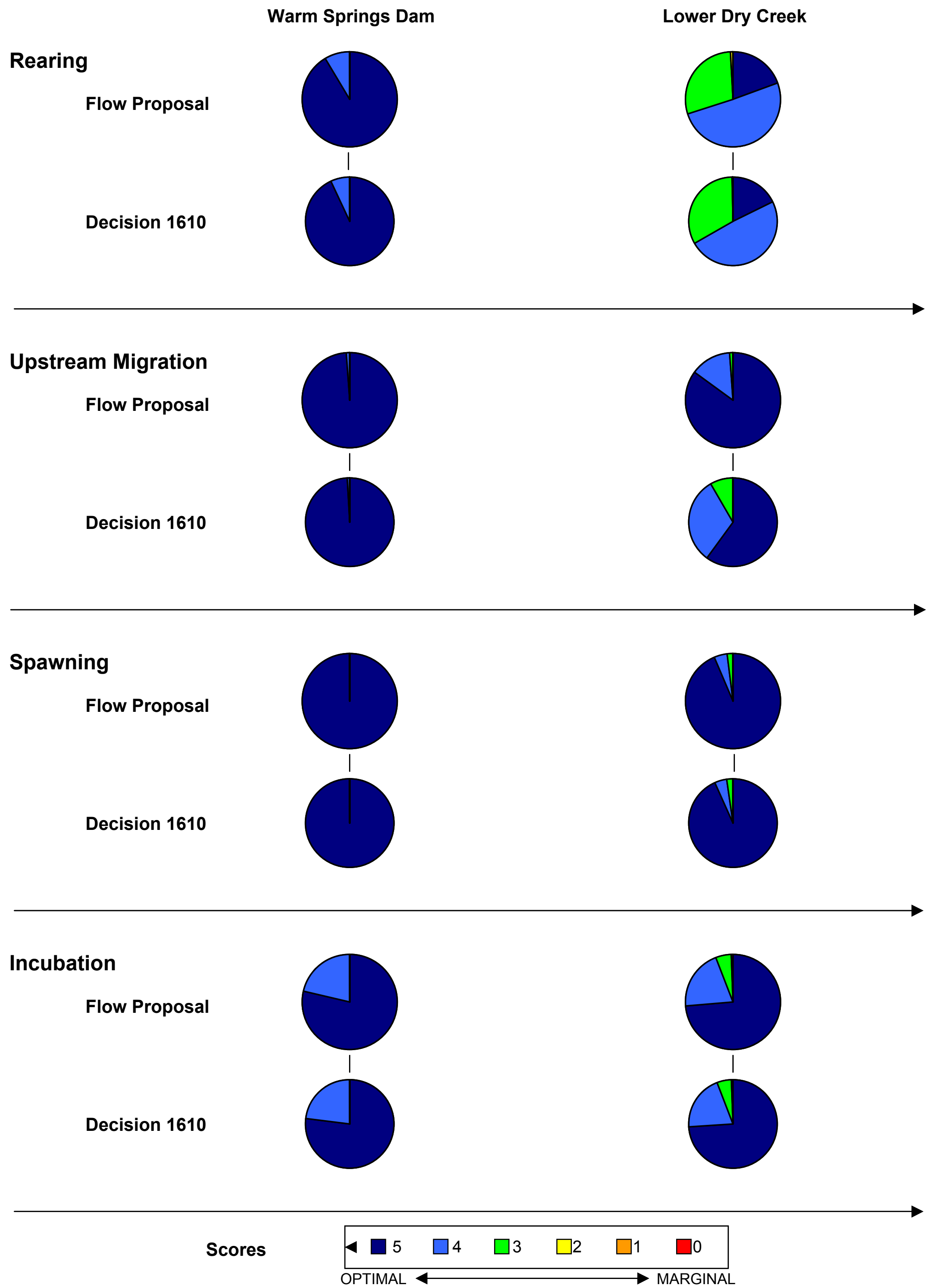


Figure 5-53 Dry Creek Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Current Demand Levels

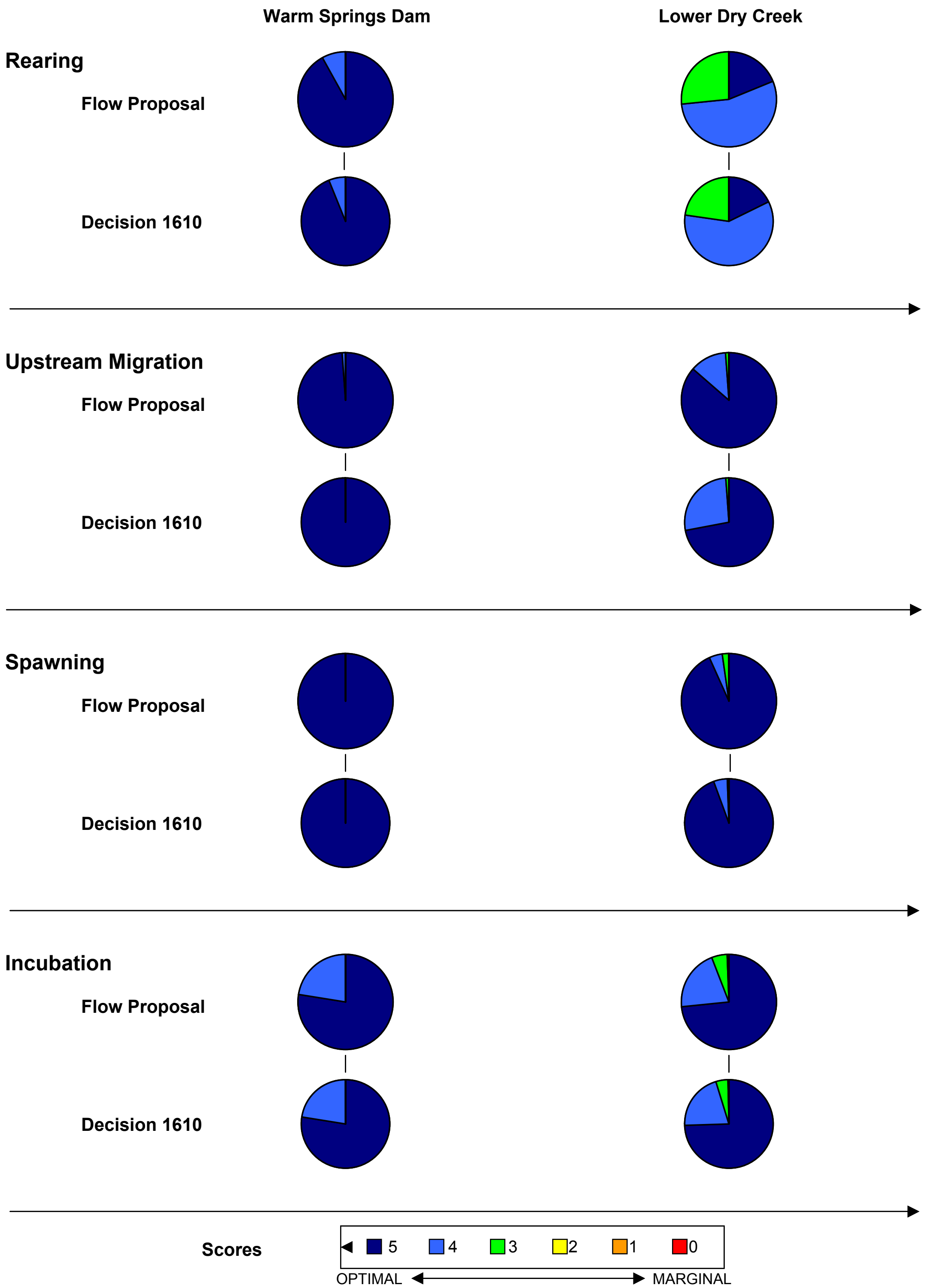


Figure 5-54 Dry Creek Chinook Salmon Temperature Scores for Dry Water Supply Conditions at Buildout Demand Levels

5.4 CHANNEL MAINTENANCE

The effects of the following four general channel maintenance activities on listed fish species in the Russian River watershed were evaluated and are presented below.

- Sediment maintenance
- Debris clearing
- Vegetation maintenance
- Bank stabilization

Effects of operation and maintenance of flood control reservoirs were also evaluated. Channel maintenance in the Russian River mainstem and Dry Creek was evaluated for activities related to construction and operation of Coyote Valley and Warm Springs dams and for specific federal and nonfederal (Public Law 84-99) sites.

SCWA would continue to perform channel maintenance in the Russian River and its tributaries in Sonoma County, and MCRRFCD would continue to perform channel maintenance in the Russian River in Mendocino County.

5.4.1 ISSUES OF CONCERN

Channel maintenance and NPDES permit activities may have direct and indirect effects on listed fish species and their habitat. There may be both immediate, direct effects of channel maintenance activities during implementation, and effects that may persist after a maintenance activity has been completed as a result of channel geomorphic or fish habitat alteration. For example, riprap installation for bank stability control may have immediate effects related to equipment working in a channel with water. After installation, the riprap may have effects on the amount of cover, water temperature, or other habitat conditions that persist over time.

Issues of concern include:

- Immediate, direct effects from construction and operation and maintenance activities:
  - Increased fine sediment and turbidity.
  - Injury to listed fish species due to equipment operation.
  - Direct mortality or injury to listed species due to chemical release for vegetation control.
  - Entrapment or injury of listed fish species at flood control reservoirs.
- Alterations to habitat from:
  - Streambank and streambed stabilization
  - Sediment maintenance
  - Debris clearing

- Vegetation control
- Passive operation of flood control reservoirs

- Indirect effects from NPDES stormwater discharge permit activities

SCWA would conduct channel maintenance activities for flood control on more than 300 miles of streams within Sonoma County, most of which are located in the Russian River watershed (Central Sonoma Watershed Project and Mark West Creek watershed, Rohnert Park, Cotati, and Sebastopol channels).

Gravel-bar grading and vegetation removal related to bank stabilization in the Russian River would be conducted under different protocols to minimize injury to fish or sedimentation in habitat. These activities were evaluated. Emergency bank stabilization work conducted in natural waterways, including the Russian River, is also discussed in this section.

Activities and protocols related to gravel-bar grading in the Russian River to increase infiltration to the aquifer beneath the river evaluated in Section 5.4.5. These activities differ slightly from gravel-bar grading activities for flood control purposes evaluated in Section 5.4.2. Finally, indirect effects from NPDES stormwater discharge permit activities were also evaluated.

5.4.2 Central Sonoma Watershed Project and Mark West Creek Watershed

Under the proposed project, channel maintenance activities would continue to be conducted on specific constructed flood control channels and natural waterways (see Tables 3-12 and 3-14). Some of the natural waterways were straightened, shaped, and stabilized between 1958 and 1983. Routine sediment removal would not be performed in these natural waterways, except in response to an emergency event (see Section 5.4.4). Operation and maintenance of flood control reservoirs were also evaluated for effects on listed fish species.

5.4.2.1 Sediment Maintenance and Channel Debris Clearing in Constructed Flood Control Channels

SCWA is responsible for sediment maintenance activities in constructed flood control channels to maintain channel flow capacity. Under the proposed project, SCWA would conduct sediment removal as-needed in constructed flood control channels. Although sediment deposits occur to some degree in many of the flood control channels, sediment maintenance work would be needed primarily in channels located in the Rohnert Park-Cotati area.

Sediment removal from constructed flood control channels would be performed when field inspections indicate that the invert elevation of outfall channels is generally less than 12 inches above the streambed. Sediment removal would be performed during the summer or fall months (until October 31) when most flood control channels are dry. However, in some years sediment removal activities may occur in channels with isolated, standing pools or with small amounts of flowing water that are, in part, derived from urban return flows (such as water from lawns). Because sediment removal activities take place during the summer and fall, the life-history stages that potentially could be directly affected are rearing juvenile steelhead or coho salmon.

Limited and Poor-Quality Habitat

Salmonid rearing habitat in most of the constructed flood control channels is very limited and is of marginal quality where it does exist. Therefore, flood control channels may serve primarily as migration corridors to and from upstream spawning and rearing habitat. Good-quality habitat is located in the Mark West Creek watershed, so fish passage in constructed channels in that watershed is especially important. Flood control channels in the Rohnert Park-Cotati area have very limited and poor-quality rearing habitat due to:

- Very low to dry summer flow conditions
- Poor water quality due to urban runoff
- Straightened channel
- Low-channel gradients
- Susceptibility to sediment deposition

Juvenile rearing habitat is mostly unavailable in streams draining the Rohnert Park-Cotati area because many of these channels are often naturally dry, or have very low flows during the summer. Dry or very low summer flows were most likely the predominant historical condition that existed in these channels. Pool/riffle type habitat that is necessary for successful salmonid rearing is poorly developed due to the straightened channel. Channel straightening, which is an integral part of the flood control design, eliminates natural channel sinuosity (i.e., meandering). Sinuosity is an important element of the natural channel geomorphology that promotes pool development on outside bends of meanders, and bar development on the inside of the meander. Because the flood control channels are permanently straightened, the formation of pool-bar units within a meandering channel is inhibited. This lack of corner pools and bars limits the availability of rearing habitat.

Sediment deposits occur to some degree in many of the SCWA flood control channels. Deposition negatively affects flood capacity and requires excavation most frequently in those channels that have a relatively low gradient such as flood control channels in the Rohnert Park-Cotati area (see Figure 3-6). The average flood control channel gradient is approximately 0.2 percent. In channels that tend to require excavation in the Rohnert Park-Cotati area, gradients are often even lower than 0.2 percent. Sediment deposition reduces the depth and capacity of pools (if they are present), thereby limiting the quality and availability of rearing habitat. In combination, the lack of summer flows and limited amount and depth of pool habitat is likely to cause high summer water temperatures to occur in the flood control channels. Large diurnal temperature fluctuations that also limit the quality of juvenile rearing habitat can also occur.

For all of the reasons presented above, rearing habitat is likely to be extremely limited or not present in those Rohnert Park-area flood control channels that require sediment removal to maintain flood capacity. A few salmonids may rear in these channels during the summer months, but the primary function of these channels would be as a migration corridor. Steelhead are the most abundant of the listed species present in these channels. Coho salmon and Chinook salmon may also use portions of these channels, but are unlikely to be either widely distributed or to be a significant presence (see Section 2.2.4). Due to the limited presence of salmonids in the flood control channels, effects of sediment maintenance in the channels is presumed to have little or no effect on listed salmonid species. Effects to salmonids are evaluated for direct injury to fish and for long-term changes to habitat.

Direct Injury to Fish

Direct effects of sediment removal are evaluated based on the level of instream and upslope sediment control and on the opportunity for injury to fish. Injury to fish can be caused by increases in turbidity and sediment input, stress from displacement, or direct injury or mortality from maintenance equipment. When sediment maintenance activities occur in streams with flowing water, flow would be bypassed around the work area. Alternatively, sediment containment may consist of the placement of barrier across the channel. This type of barrier slows the water flow, allowing suspended sediment to settle out where it can be cleared following maintenance activities. The current sediment containment practices are likely to result in effective sediment control, because they allow a limited amount of fine sediment to be introduced within the immediate area. Therefore, the score for sediment removal practices for component 1 of the sediment containment evaluation criteria is 3 (Table 5-36) (see Appendix C for a detailed discussion of evaluation criteria).

The use of heavy equipment on a streambank could potentially result in “upslope” disturbance (for sediment-removal activities in flood control channels, upslope is synonymous with the streambank). SCWA would not use equipment on the streambank, but rather would continue to work from service roads adjacent to the channel or within the channel bottom. Occasionally, construction of a new access road to the stream bottom may be necessary, however, disturbance of the streambank would be limited to discrete areas. The use of existing access roads limits the amount of streambank disturbance, protecting vegetation and soil structure. Therefore, the risk of a direct effect on rearing salmonids due to this type of activity is low. Component 2 of the sediment containment evaluation criteria receives a score of 4 (Table 5-36).

Sediment removal and channel-clearing activities have the potential to injure or kill fish when equipment is operated in the channel. Fish that would be temporarily displaced may be subjected to stress, increased competition, or predation. SCWA biologists would assess habitat conditions prior to sediment removal to determine if listed fish species are present in the maintenance area. In past inspections, SCWA has found that salmonids are not usually present in these areas during the time of year that the work is performed (A. Harris, SCWA, pers. comm. 2000). If listed salmonids are present, a barrier would be established to exclude fish from the immediate area of the activity, and a fish rescue would be performed, if necessary. Because efforts would be taken to avoid effects on listed species by exclusion from the area affected or relocation to other habitat, the risk of injury would be low. Therefore, sediment removal and channel-clearing activities receive a score of 3 (Table 5-37).

Table 5-36 Sediment Containment Evaluation Scores for Sediment Removal

Category Score	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	Co, St, Ch
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-37 Opportunity for Injury Evaluation Scores for Sediment Removal

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Co, St, Ch
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

The level of risk for injury to fish depends, in part, on how much of the channel would be "cleaned" and how often the work would be performed. Table 5-38 lists the constructed flood control channels and provides estimates on the extent and frequency of sediment removal activities. Many of these channels have never required sediment maintenance (i.e., they are self-maintaining). Some require maintenance every year.

Table 5-38 Frequency and Extent of Sediment Removal in Constructed Flood Control Channels (as of 2003)

Creek	Total Constructed Channel Length (ft)	Percent of Channel Worked	Average Bottom Width (ft)	Frequency of Work	Recently Cleaned*	Comments
Santa Rosa Area Streams						
			Rearing and/or Spawning Habitat			
Brush	12,100		25	>20 yrs		Self cleaning
Oakmont	6,600		20	> 10 yrs		Hydraulic only/ no sediment removal
Paulin	15,400		20	>20 yrs		Self cleaning
Piner	12,000	50%	20	>10 yrs	1989	Remove sand bar at Sleepy Hollow Ct.
Santa Rosa	48,400		30/40	>20 yrs		Self cleaning
Todd	15,400	40%	20	5-10 yrs		Not cleaned in last 5 years
			Migration Only			
Austin	5,000		20	>20 yrs		Self cleaning
Colgan	19,250	50%	30	5-10 yrs	2000	From Stony Point Rd to Llano Rd.
College	4,400		15	>20 yrs		Self cleaning
Forestview	3,850			>20 yrs		Self cleaning
Indian	1,650	100%	10	>10 yrs	1999	From Piner Rd. north 2,000 ft
Kawana Springs	2,200	100%	20	10-20 yrs	1988/89	Petaluma Hill to Colgan Creek
Lornadell	1,200	100%	15	5-10 yrs	1987/88	Not cleaned in last 5 years
Matanzas	2,500	100%	35	>10 yrs	1988/89	Last cleaning
Peterson	8,800		15	>20 yrs		Self cleaning
Roseland	23,000		25	5-10 yrs		Not cleaned in last 5 years
Russell	3,800	100%	15	5-10 yrs	1989/97	From Mendocino Ave to Indian Creek
Sierra	1,600		15	>20 yrs		Hydraulic only/ no sediment removal
Steele	12,000	20%	15	10-20 yrs	2003	
Wendell	6,100	50%	15	5-10 yrs		Not cleaned in last 5 years
Windsor	5,000	50%	20	5-10 yrs		Not cleaned in last 5 years

Table 5-38 Frequency and Extent of Sediment Removal in Constructed Flood Control Channels (as of 2003) (Continued)

Creek	Total Constructed Channel Length (ft)	Percent of Channel Worked	Average Bottom Width (ft)	Frequency of Work	Recently Cleaned*	Comments
Cotati-Rohnert Park Area Streams						
			Rearing and/or Spawning Habitat			
Laguna de Santa Rosa	24,200	10%	40	5-10 yrs	1992/93	East Cotati Ave to Commerce Blvd.
			Migration Only			
Coleman	3,300		20	1-5 yrs	1997	Cleaned upper reach 2 times in Golis Park in last five years
Copeland	19,250	100%	30	1-3 yrs	2000	Commerce Blvd to Jasmine Ct. 12,100 ft
Copeland South Fork	4,000	100%	15	10-20 yrs	1986/87	Last cleaning
Cotati	1,000	100%	15	5-10 yrs		Not cleaned in last 5 years
Crane	800	100%	15	5-10 yrs	1991/92	Not cleaned in last 5 years
Five	6,600	100%	25	5-10 yrs	2000	From Snyder to Country Club
Gossage	7,700	90%	15	5-10 yrs	1989/98	Gravenstein Hwy (Hwy 12) to Laguna de Santa Rosa
Hinebaugh	13,200	25%	25	1-5 yrs	1989,95, 99	3 separate reaches of approximately 1,000 ft
Hunter Lane Channel	6,600	100%	20	5-10 yrs	2000	Santa Rosa Ave to Hunter Lane
Spivok	1,600		10	5-10 yrs		Not cleaned in last 5 years
Washoe	1,600	100%	15	5-10 yrs		Not cleaned in last 5 years
Wilfred	22,000	100%	15	5-10 yrs	1989/95	From Laguna de Santa Rosa to Snyder Lane
Healdsburg Area Streams						
Norton Slough	6,600	100%	20	1-5 yrs	1987/88, 2001	Planned for future
Windsor Area Streams						
Starr	2,500	100%	15	10-20 yrs	1985/86	Last cleaning
Geyserville Area Streams						
Woods	3,500	30%	15	1-5 yrs	1995, 98, 99	Cleaned approx 500 ft near rail road tracks

*Some creeks that have not required recent cleaning may require cleaning in the future.

Overall, sediment removal activities may adversely affect a few individual juvenile coho salmon, steelhead, or Chinook salmon, but are not likely to result in a population-level effect for any of the three listed species. Disturbance to the streambank would be kept to a minimum, and effective sediment control practices would be used during instream work in wetted channels. Channels would be assessed by SCWA biologists before sediment removal activities would be performed, and in the rare instances that it is determined that listed species are likely to be present, a barrier would be established to exclude fish and, if necessary, rescue would be performed. To date, barriers and fish rescues have not been necessary (S. White, SCWA, pers. comm. 2004). Because sediment-laden constructed flood control channels do not generally provide rearing habitat for coho salmon or steelhead, they are likely to have few, if any fish present, so the risk for injury to fish is low. While some individual fish may be exposed to injury, there is low risk to any of the populations of listed fish species, as a whole.

Long-Term Changes to Habitat Associated with Sediment Removal

Under baseline practices, sediment maintenance activities would remove all sediments from constructed channels to maintain channel capacity. Under the proposed project, sediment removal would only be conducted on an as-needed basis, which could result in less intensive sediment removal in some channels. Sediment removal activities that may have long-term habitat effects on fish migration include reduction of habitat complexity such as loss of a low-flow “thalweg” needed to provide fish passage, and loss of instream cover (rocks, vegetation). In the past, such habitat features were often removed within reaches that were excavated. Under the proposed project, where possible, a meandering thalweg would be left to provide for fish passage. However, in the few areas where more extensive sediment removal may have to occur to maintain channel capacity, the loss of a low-flow channel may result in a loss of fish passage opportunities. The effects of sediment maintenance activities were evaluated, based on the amount of work that would be needed and on available information on salmonid use of a particular stream.

Table 5-38 lists the constructed flood control channels and the estimated frequency of maintenance related to sediment removal (P. Valente, SCWA, pers. comm. 2003). Estimates of the channel length (defined as a percentage of total channel length) where work is usually performed are indicated. This percentage does not represent a continuous length of channel in which sediment would be removed, since the actual maintenance work typically would be performed at discrete, selected sites. Only that portion of the channel reach that is hydraulically impaired would be cleaned. The frequency and length of work varies over time. In the past, flood control channels were cleaned at least once every five years. Currently, channel cleaning would be restricted to an as-needed basis to maintain flood capacity. For example, 100 percent of Copeland Creek (i.e., 100 percent of the constructed flood control channel) was cleaned once in 1997, but only 17 percent (2,000 feet) required cleaning in 2000. The frequency of work may change in the future if land-use practices or development occurs that alters sediment supply conditions in the sub-basins draining the flood control channels.

One of the largest recent sediment removal activities was performed in 1997 in a 2.5-mile stretch of Copeland Creek located upstream of Petaluma Hill Road outside of Rohnert

Park. Sediment input from a large runoff area upstream resulted in significant sediment loads being delivered to the creek (R. Anderson, SCWA, pers. comm. 2000). SCWA worked on restoring approximately 6,000 feet of streambank upstream on Copeland Creek to reduce streambank erosion (see Section 5.5 for details of this and other erosion control projects). However, low summer flows and high summer water temperatures may limit rearing habitat in the restored reach of Copeland Creek.

Sediment was removed from a wide section of Hinebaugh Creek west of the freeway in 1999. Sediment is deposited there when backwater from Laguna de Santa Rosa enters the creek. Coleman Creek has a short segment of constructed channel through a local golf course that requires sediment removal activities. Increased sedimentation in this creek may be due to upstream development. It is expected that the Cook Creek Conduit Sediment Basin upstream of Rohnert Park, completed in 1998, will help to reduce some of the sediment input to Coleman Creek.

Most of the constructed flood control channels that are subject to frequent sediment removal activities function primarily as migration corridors for upstream and downstream migrants during the winter and spring. Summer rearing habitat and spawning habitat is not typically found in constructed channels subject to sediment removal.

Effects on Salmonid Migration

In general, sediment removal activities are needed in channel reaches that contain poor habitat and significant sediment deposition. These channels function primarily as migration corridors. Small lateral bars are observable in many locations along the channel bottom. These deposits are usually stabilized by either grasses or tules. The sediment deposits are primarily silt and clay. These small lateral bars and other deposits narrow the bottom width of the channel, and tend to create a more “natural” sinuous low-flow path within the straight flood control channel.

Observations made following sediment removal activities indicate that the channel bed is devoid of the small lateral bars and associated in-channel vegetation. The loss of a sinuous, narrow, low-flow channel allows the streamflow to spread over the bottom width, reducing depth. This reduction of flow depth creates a fish passage barrier when runoff is relatively low. Reduced depth of flow can be expected to occur whenever lateral bars are removed, eliminating a low-flow thalweg and widening the channel bottom. As a result, migration is limited to periods when flows are higher and depth is adequate for passage.

Lateral bar features eventually become reestablished following runoff events capable of mobilizing and redistributing bed sediments, and vegetation has had an opportunity to colonize and stabilize the bars. Vegetation on the streambed bars may take more than one season to become reestablished.

The post-sediment removal effects on passage conditions were evaluated on Copeland Creek and Five creeks. Sediments were excavated from sections of both channels during fall 2000. Following sediment removal, water depths in the excavated portions of both streams were estimated to average 2 to 3 inches during a field inspection. In the unexcavated portions of these channels, depths were a minimum of 6 inches. Figure 5-55 shows an excavated section of Copeland Creek with a wide, shallow, and flat streambed in December 2000. Figure 5-56 shows an unexcavated section of Copeland Creek from the same date, with a narrowed channel bottom and vegetated lateral bars. Steelhead generally require a minimum of 6 inches of depth for migration (Flosi et al. 1998).

Given the 2- to 3-inch depths observed on Copeland and Five creeks, fish passage is likely to be impaired following sediment maintenance. Based on the types of habitat alteration that occurs, sediment removal can negatively affect migration in constructed flood control channels during low flows.

SCWA is evaluating the possibility of reestablishing some sinuosity to low-flow channels within the wide streambeds of the flood control channels following sediment maintenance activities. Outside bends would be stabilized with natural materials to produce longevity of the meander patterns. This action would create increased depth in the corner pools and overall, to allow improved fish passage and juvenile rearing conditions.

Effects on Rearing and Spawning Habitat

Of the stream channels identified that potentially support salmonid rearing habitat only two have required frequent (once every 5 to 10 years) sediment removal activities in the recent past, although additional channels may require more frequent maintenance in the future for flood control. The two channels are Laguna de Santa Rosa in the Rohnert Park area and Todd Creek in the Santa Rosa area. The basis for identifying these channels as potentially supporting rearing habitat is that they either maintain flow through the summer season or steelhead have been known to occur in them. Both channels are likely to require additional sediment maintenance in the future. The remaining channels that potentially support salmonid rearing habitat have been maintained less frequently (once every 10 to 20 years). Rearing habitat could be disturbed in these channels, and the effects of that disturbance may persist for several years. However, primary rearing habitat is not expected to be found in these constructed flood control channels, so the loss of some rearing habitat would not be substantial.

Spawning habitat is generally not present in the constructed flood control channels that require sediment maintenance, for reasons similar to those discussed regarding the lack of rearing habitat. Low-gradient, straightened channels that are subject to sediment deposition do not generally provide any or good spawning habitat conditions. Observations of flood control channels indicate that suitable spawning sites such as gravel deposits at pool tailouts are very infrequent and limited in extent. Lack of hydraulic complexity probably accounts for limited sites where sorting of gravels forms suitable spawning riffles. This is due to the straight channel and entrenched (vertical containment) geomorphic condition of the flood control channels. There are no known reports or observations of spawning occurring in constructed flood control channels that

Figure 5-55 Copeland Creek downstream from Snyder Lane, December 2000. Channel reach was excavated in October 2000.

Figure 5-56 Copeland Creek downstream of Country Club Drive, December 2000. This reach of Copeland Creek has not been recently excavated. Note the vegetated lateral bars and the narrowed channel bottom.

require sediment excavation. Of the constructed flood control channels, Oakmont, Paulin, and Santa Rosa creeks are believed to provide salmonid spawning habitat. However, these channels generally have been maintained infrequently (once every 10 to 20 years).

While the availability of spawning habitat may potentially be reduced in some years, the activities occur infrequently so the effects on the availability of spawning habitat would not be high. Because the availability of rearing habitat is more likely to be the limiting factor for salmonids than the availability of spawning habitat, the effects to listed fish species is likely to be low.

Sediment removal in Todd Creek and Laguna de Santa Rosa could reduce rearing habitat by eliminating pools and associated cover within the excavated reach. Sediment excavation flattens the bed topography, reducing hydraulic and habitat complexity. This is likely to be a significant effect for coho salmon and steelhead, which are the two listed fish species most likely to be present in these channels. The effect would be localized in the excavated reach only and not extend to areas downstream.

Sediment excavation does not affect other aspects of channel geomorphology or aquatic habitat downstream of the excavated reaches. Observations of the flood control channels indicate that there are relatively few sites where sediment deposition occurs within the well-entrenched and straightened flood control channels. There is also very little evidence of channel incision due to sediment excavation based on the inverts of culverts and bridge crossing structures. Excavation has apparently not significantly reduced sediment supply to reaches downstream of maintained areas. Additional sediment that would be transported downstream if this maintenance activity ceased would most likely lead to channel aggradation, and possibly increased erosion of channel banks. This would cause a loss of not only channel flood capacity, but would allow additional sediments to reach Laguna de Santa Rosa and ultimately the Russian River. The Russian River drainage is identified by the NCRWQCB (Section 303-D) as impaired for sediment.

5.4.2.2 Vegetation Maintenance in Constructed Flood Control Channels and Natural Waterways

Vegetation maintenance practices differ between natural waterways and constructed flood control channels. Salmonids use both types of channels for migration, although rearing and spawning is known to occur in only a few flood control channels. Removal of riparian vegetation has the potential to reduce cover for rearing salmonids, increase water temperatures, reduce the input of vegetation on aquatic insects that support the food chain for salmonids, and decrease bank stability (in natural waterways), which increases the potential for erosion and sedimentation.

The assessment of vegetation maintenance effects was organized into the two principal channel groupings: constructed flood control channels and natural waterways. The assessment of direct immediate effects to fish populations associated with herbicide spraying in natural waterways was also evaluated.

Constructed Flood Control Channels

<u>Short-Term Direct Effects of Vegetation Removal</u>

The principal short-term direct effect of vegetation control in constructed flood channels would be the potential for direct injury to fish from the introduction of herbicides into streams. In the past, access roads were sprayed with long-lasting herbicides that are toxic to fish and aquatic insects if they were to leach into the stream. Since the early 1990s, only an EPA-approved, glyphosate-based, aquatic contact herbicide (such as Rodeo™) has been used. An herbicide such as Rodeo is much more expensive than some herbicides, but substantially reduces the risk to listed species and aquatic life that supports their food chain. An aquatic contact herbicide would continue to be used in the bottom of narrow channels, as well as hand-clearing, particularly to remove cattails.

Maintenance activities have the potential to introduce herbicide to the channel. Roads will continue to be sprayed with an herbicide approved for aquatic use and mowed once a year, beginning in summer and continuing to the fall. The herbicide would be sprayed in a narrow width, and care would be taken to not spray the herbicide too close to the edges of creeks. Residual vegetation would then mowed. The area between the access roadways and the fence lines that border the channels would be mowed annually. As glyphosate degrades relatively quickly, it is unlikely that herbicide would leach into the channel. The roads adjacent to the low-flow channels in Rohnert Park would be mowed, but no herbicide would be applied. Therefore, a score of 4 was assigned to this limited use of an aquatic use approved rapidly degrading herbicide (Table 5-39).

Table 5-39 Vegetation Control Scores Associated with Herbicide Use

Category Score	Evaluation Criteria Category	Current Operations Score
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use.	Co, St, Ch
3	Moderate to heavy use of herbicide approved for aquatic use.	
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook

<u>Long-Term Indirect Habitat Effects Associated with Vegetation Maintenance Practices</u>

This section evaluates effects of three levels of vegetation maintenance: original design capacity, intermediate, and mature riparian vegetation maintenance. The evaluation considered effects that would occur based on projected maintenance needs for channels that are likely to contain habitat for salmonids. Future vegetation maintenance in some of these channels may be modified to allow the growth of more vegetation, depending on ongoing assessment of hydraulic capacity.

Frequency of vegetation control work was estimated for constructed flood control channels in which vegetation removal activities would occur (Table 5-40) (B. Oller, SCWA, pers. comm., 2003). Where rearing or spawning activity is known or suspected to occur, it is indicated. The presence of continuous summer flow (streamflow that is not supported by urban return flows) was another factor considered.

Most of the flood control channels, except Paulin, Piner, Santa Rosa, and Oakmont creeks, have conditions unsuitable for spawning because of very low gradients (between 0.05 percent and 0.4 percent foot per foot). These channels generally lack the riffles or pool-tailouts where spawning habitat is most likely to occur. Salmonids may use some constructed flood control channels as migration corridors to and from upstream spawning and rearing habitats. Channels that may potentially support summer salmonid rearing habitat within or upstream of the maintained portion but may require the original design maintenance scenario include Paulin, Piner, Santa Rosa, Brush, Crane, Laguna de Santa Rosa, Rinconada, and Todd creeks (Table 5-40).

In the past, vegetation has been maintained at the original design maintenance level to preserve the original hydraulic capacity (flood way) and reduce fire dangers. Under the proposed project, vegetation maintenance practices would be adjusted to provide better habitat conditions where feasible. Vegetation maintenance would be keyed to the channel zone and the amount of hydraulic capacity needed. Additional riparian vegetation at the intermediate or mature riparian vegetation maintenance levels would be allowed to develop, resulting in increased canopy cover in many channels. Under the proposed project, hydraulic capacity assessments would be conducted to determine the level of flood capacity needed, and this information would be used to evaluate the level of vegetation maintenance needed. Some streams that currently experience frequent vegetation clearing could be managed in a way that allows more vegetation to develop in the appropriate channel zones while preserving needed hydraulic capacity, as described in Section 4.4.

Scores for the three levels of vegetation management: original design, intermediate, and mature, are presented in Table 5-41. Under the mature riparian vegetation management, a mature riparian corridor would be allowed to develop, for a score of 5 or 4. Intermediate vegetation management would allow some vegetation to develop. Based on the estimated 30 percent of the vegetation along the channel cross section that is removed from flood control channels under current maintenance practices, the overall score for vegetation control practices would be 3. However, some channels may require more vegetation to be removed, for a score of 2.

Original design management would generally maintain the channel at or near the original design capacity of the channel. With the original design maintenance level, it will be necessary for SCWA to remove vegetation in the channel such that only vegetation near the top of the bankfull channel, and set back from the top of the bank, would be allowed to establish. This would represent approximately a 75 percent or greater reduction in vegetation within the channel cross section. The resulting score would be 1, indicating a

Table 5-40 Levels of Vegetation Maintenance Work in Flood Control Channels[1]

Creek	Summer Flow[2]	Species Known to Occur[3]	Potential to Support Spawning/Rearing Habitat
Streams that Require Original Design Maintenance Scenario			
Migration, Rearing, and Spawning			
Paulin	Yes	St	Yes
Piner			Yes
Santa Rosa	Yes	Co, St, Ch	Yes
Migration and Rearing			
Brush		St	Yes
Crane			Yes
Laguna de Santa Rosa	Yes	St	Yes
Rinconada	Yes		Yes
Todd		St	Yes
Migration Only[4]			
Austin[5]		St	Yes
Coleman			
Colgan			
Copeland			
Cotati			
Ducker			
Five			
Forestview			
Hinebaugh		Ch	
Kawana			
Lornadel			
Roseland			
Gossage / Washoe			
Wilfred	Yes		
Windsor	Yes		
Streams that Require Intermediate Vegetation Maintenance			
Migration, Rearing, and Spawning			
Oakmont	Yes		Yes
Migration Only[4]			
College			
Faught			
Hunter Lane Channel		St, Ch	Yes
Indian			
Peterson			
Russell			
Spivok			
Starr			
Steele			
Wendel			
Windsor tributaries			
Streams with Mature Riparian Vegetation Management			
Sierra Park			
Spring			
Wikiup			

1 Source: SCWA (Paul Valente and Bob Oller, Operations & Maintenance Department).
2 Summer base flow that is not supported by relatively recent urban runoff. Portions of these channels dry up in summer, but other portions retain base flow.
3 Where rearing activity occurs, species are listed if known. Salmonids may use other channels currently or in the future. Co = coho salmon; St = steelhead; Ch = Chinook salmon
4 Migration corridor assumed to be a function of all flood control channels.
5 Austin Creek in Rincon Valley, not in West Sonoma County.

Table 5-41 Vegetation Control Scoring for Flood Control Channels

Category Score	Evaluation Criteria Category	Score
5	No removal except selectively along access roads, fencelines, “spot” treatments, or to remove non-native species.	Mature riparian vegetation management
4	<25% reduction in vegetation.	Mature riparian vegetation management
3	>25% to <50% reduction in vegetation.	Intermediate vegetation management
2	>50% to <75% reduction in vegetation.	Intermediate vegetation management
1	>75% reduction in vegetation.	Original design management

potentially significant effect on listed salmonid species and their habitat. It is recognized that there is a potential for greater effects on habitat conditions associated with those channels that are most likely to support rearing or spawning habitat.

Vegetation removal on some channels under this level of vegetation maintenance would result in increased water temperatures that could be detrimental to salmonids. Removal of understory vegetation may result in a decrease in cover for salmonids and habitat for invertebrates on which the fish feed.

Under the intermediate or mature riparian vegetation management, shade canopy may become established in some of these flood control channels due to tree growth on the streambanks. Under these conditions, it is expected that there would be less need to remove understory vegetation, and therefore, reductions in canopy cover would become less frequent. Modified vegetation maintenance practices are likely to increase the long-term habitat value of channel reaches over existing conditions by increasing canopy cover, and decreasing water temperatures in the summer. Also, by targeting non-native vegetation for clearing and allowing native species to become established, the chances for a naturally functioning ecosystem to become established increase. The effect of reestablishing a naturally functioning ecosystem would be of particular benefit to coho salmon, steelhead, and Chinook salmon. These effects are already being seen in Brush, Santa Rosa, and Hinebaugh creeks where significant tree growth has occurred.

Existing vegetation maintenance practices in constructed flood control channels have been reviewed by SCWA to determine their influence on channel flood capacity. Vegetation growth must be balanced with flood capacity. As vegetative growth on the streambanks become more dense and mature, channel capacity could be significantly reduced, and flooding could occur. In order to prevent flooding and maintain flood capacity, the original design capacity maintenance practices would be required in some segments of constructed flood control channels.

Most flood control channels that require frequent or extensive maintenance do not provide good quality spawning and rearing habitat. Some flood control channels have poor habitat in the constructed portion of the channel, but may have spawning or rearing habitat in the upper portion. In these, the primary effect of vegetation management in the constructed channel would be on upstream or downstream migrants.

Effects would be of greater significance to populations as a whole for those flood control channels that support rearing and/or spawning habitat. Ten flood control channels have been identified that potentially support spawning and/or rearing habitat, nine of which have reaches that require the original design maintenance scenario:

- Brush
- Crane
- Laguna de Santa Rosa
- Oakmont
- Todd
- Paulin
- Piner
- Rinconada
- Santa Rosa
- Hunter Lane

In some cases, vegetation maintenance is conducted in a small area. For example, the area below Brush Creek encompasses approximately a 50-foot radius. Removal of brushy vegetation from such a small area is not likely to affect salmonid habitat, particularly since these areas are dry during the summer and no fish rearing would take place at that time. Removal of non-native weeds (like hydrilla) may benefit salmonid habitat downstream, as does removal of fine-grained sediments.

Evaluation criteria provide an estimate of the long-term indirect effects on habitat depending on the extent of vegetation removal practices. For some of the flood control channels that do not support rearing or spawning habitat, there may be an effect on salmonid migration. In those channels where a low-flow thalweg can be maintained, fish passage may not be substantially affected. For segments of the nine of the ten channels that have been identified as providing potential rearing and/or spawning habitat, the original design maintenance practices may have localized effects that would be greater.

Natural Waterways

Table 5-40 lists the natural waterways maintained by SCWA in the Russian River watershed. Past practices that may have resulted in degradation to native riparian vegetation and to instream vegetation on natural waterways have been greatly modified. Previously, riparian vegetation was extensively removed. Under the proposed project, protocols would be implemented to retain as much canopy cover as possible (see Section 4.4). Vegetation would be removed by hand, brush would be removed, and trees and limbs would be removed only if required for flood protection. SCWA maintenance practices include a buffer strip of vegetation along the low-flow channel margin. Efforts would be made to preserve the natural habitat for fish and riparian wildlife. These activities are not expected to result in direct injury to listed species. SCWA has coordinated in-channel vegetation maintenance with NOAA Fisheries. Several alternative vegetation maintenance methods are being considered, including selective vegetation removal based on vegetation density, height, or stem diameter. Along streambanks, understory vegetation (blackberries and willows) is removed, but native trees are retained to provide canopy cover along natural waterways.

Although limited vegetation removal in isolated sites may not negatively affect salmonid habitat, work done over several sections of a stream and/or in prime spawning and rearing habitat, may have a larger net effect. For example, if willows are removed from several gravel bars to reduce the potential for streambank erosion in an important coho salmon stream, the net effect may be to significantly alter channel morphology, the amount of instream cover, and the availability of refugia from high flows. To avoid significant effects to salmonid habitat, vegetation removal in natural waterways would be kept to a minimum and used only when the hydraulic capacity of the channel does not meet the original design flood capacity (typically 100-year flood event on most channels) or where a decrease in bank stability threatens a structure. For most projects, vegetation maintenance would be conducted within stream reaches that are each between 300 and 600 feet in length.

Vegetation Maintenance Scores Associated with Natural Waterways

Current practices emphasize retention and creation of a shade canopy over stream channels to reduce plant growth on the channel bottom and to benefit salmonid habitat quality. Native trees are allowed to establish, and understory in the channel and along the banks is judiciously removed. Generally, the understory is thinned and lower limbs on trees are pruned (to raise the canopy) to improve flood capacity.

For the natural waterways where vegetation removal may occur SCWA removes vegetation on these other natural waterways only where there are site-specific problems with flood capacity or bank stability. Therefore, the length of vegetation removal would be limited to small projects, generally 300 to 600 feet in length. It is difficult to estimate the percentage of vegetation that may need to be removed in a cross sectional area from any of these given channels because they vary in maintenance needs. However, since SCWA practices in natural waterways call for underbrush removal and retention of a shade canopy over stream channels, it is reasonably estimated that no more than 25 percent of the in-channel vegetation would be removed, resulting in a score of 3 (Table 5-42).

Table 5-42 Vegetation Control Scores for Natural Waterways

Category Score	Evaluation Criteria Category	Score
5	No vegetation removal except "spot" treatment, or removal of only non-native species.	
4	<10% reduction in vegetation.	
3	>10% to <25% reduction in vegetation.	St, Co, Ch
2	>25% to <50% reduction in vegetation.	
1	>50% reduction in vegetation.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

While individual projects may be small, the sum of several projects may have larger effects, especially if they occur in important salmonid spawning and rearing habitat such as some of the natural waterways in Mark West Creek and its tributaries or the natural waterways in the western, coastal-fog influenced portions of the watershed. Therefore, removal of instream and streambank vegetation would be kept to a minimum in these streams (i.e., only where significant flood control hazards or threats to structures exist). Vegetation removal in streams with limited rearing habitat (for example, some natural waterways in the Rohnert Park area) would not be as likely to diminish salmonid habitat, and therefore could safely be more extensive. Current vegetation removal activities, therefore, have a relatively low risk of short-term or long-term indirect effects to salmonid habitat (particularly coho salmon and steelhead) in natural waterways.

Herbicides may be selectively used in natural waterways to reduce dense stands of *Arundo*, cattails, and blackberries. Spraying in natural waterways would be done only when the channel flood capacity has been significantly reduced. This practice has become more common on streams where urban or irrigation return flows support vegetative growth throughout the summer. When spraying is necessary in natural waterways, it would be conducted in focused areas, generally for project lengths of 100 to 500 feet of stream (B. Oller, SCWA, pers. comm. 2000). A score of 4 is therefore given for herbicide applications in natural waterways (Table 5-43), due to the very limited, infrequent and site-specific extent of use with approved herbicides. A score of 4 for herbicide use indicates that only minor effects to listed salmonid species are expected to occur as a result of this action.

Table 5-43 Vegetation Control Scores Associated with Herbicide Use

	Herbicide use	
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use in riparian zones or over water.	Co, St, Ch
3	Moderate to heavy use of herbicide approved for aquatic use in riparian zones or over water.	
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use in riparian zones or over water.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

In some cases, restoration projects have increased riparian cover, maintained hydraulic capacity, and reduced the need for streambank or streambed maintenance activities (see Section 5.5). For example, restoration activities in Brush Creek showed that planting native trees in a straight line parallel to the stream increased riparian habitat value of the stream without significantly decreasing the hydraulic capacity. When native trees are established, either through restoration activities or through channel maintenance practices that allow native riparian vegetation to establish itself, it is expected that the need for vegetation removal activities will decrease and the fish habitat value of these streams will significantly increase. As SCWA biologists continue to work with channel maintenance personnel to restore native vegetation, the habitat value of both natural and constructed flood control stream reaches would be expected to improve over baseline conditions.

5.4.2.3 Large Woody Debris Removal

Debris removal, particularly large woody debris removal, would be conducted only when the debris poses a threat for erosion or flood control. Before large woody debris would be removed, it would be evaluated by SCWA staff. Large woody debris would be removed with a winch from the top of the bank, cut up, and transported away.

Large Woody Debris Removal in Flood Control Channels

Large woody debris plays a relatively small role in the structure and function of salmonid habitat within the Zone 1A (see Figure 3-6) flood control channels for several reasons:

- Flood control channels are not within forested regions that are sources of large woody debris.
- Flood control channels are designed to be stable so that bank erosion and associated large woody debris recruitment is minimal.
- Flood control channels are designed to contain large peak annual floods (10-, 25-, or 100-year runoff events), so that high flows prevent large woody debris from lodging in stable positions in the channel.

Typical large woody debris recruitment processes, whereby bank erosion helps large woody debris recruitment to streams, does not occur very often in flood control channels. SCWA estimates that an average of half a dozen pieces are removed from flood control channels, annually, and fewer in years with smaller storms.

Constructed flood control channels were designed to efficiently pass high flows in relatively “flashy” watersheds that are also efficient at passing even large trees. While some large woody debris may be deposited in the Laguna de Santa Rosa, most of it is washed to the Russian River. Some large woody debris from the upper watershed, such as the Hood Mountain area, is caught on trash racks or deposited in Spring Lake. This wood would continue to be removed and cut up. The effect of the flood control reservoirs on the recruitment of large woody debris is evaluated in Section 5.4.2.

Large woody debris is not likely to play a significant role in providing structure or habitat in flood control channels. This is the case today and would likely persist into the future, given the limited tree resources and recruitment processes. Therefore, the SCWA practice of limiting large woody debris removal to situations when it poses a flood control hazard would not likely result in substantial reduction of cover or scour, and the maintenance activity score is 3 (Table 5-44). The only species/lifestage that may be affected by removal of large woody debris in flood control channels would be young steelhead rearing near the debris. Removal of large woody debris can potentially reduce the amount of instream cover and habitat diversity for salmonids, as well as substrate for benthic invertebrates that serve as food. Large woody debris creates hydraulic gradients that increase microhabitat complexity and the abundance of salmonids is often linked to the abundance of woody debris, especially in the winter (Bustard and Narver 1975, Tschaplinski and Hartman 1983, Murphy et al. 1986, Hartman and Brown 1987).

Table 5-44 Large Woody Debris Removal Scores

Category Score	Evaluation Category	Current Operations Score
5	No large woody debris removal or modification.	
4	Large woody debris not removed, but modified.	
3	Large woody debris removal limited to only when it poses a flood control hazard, removal does not result in substantial reduction of cover or scour in the area.	St
2	Large woody debris removal limited, but potentially results in moderate reduction of cover or scour.	
1	Complete removal of large woody debris resulting in substantial reduction of cover or scour.	

*St = Steelhead

5.4.2.4 Central Sonoma Watershed Project Flood Control Reservoirs

Four flood control reservoirs passively reduce flooding in the Santa Rosa area during the rainy season. Three of these reservoirs are instream with minimum streamflow bypasses. These three reservoirs are impassable, acting as barriers to upstream migration for anadromous coho salmon and steelhead. A diversion structure on Spring Creek also acts as a barrier to upstream migration. Potential downstream effects of operation and maintenance on anadromous salmonids and their habitat were evaluated. Additionally, safe fish passage for downstream migrants in Santa Rosa Creek past the Spring Lake diversion was evaluated.

Brush Creek and Piner reservoirs and the Spring Creek diversion are located on ephemeral streams and are relatively small reservoirs that dry up by the summer. Matanzas and Spring Lake reservoirs have larger capacities, do not dry up during the summer, and do not spill downstream during the summer season. The Sonoma County Park Department adds water (after October when peak water demands are reduced) to maintain a recreational lake. A small tributary spring at the Spring Lake diversion facility also feeds water to Spring Lake. Spring Lake is located offstream and receives water from Santa Rosa Creek only during high flows that occur about once a year (A. Harris, SCWA, pers. comm., December 24 2003).

Evaluation of Immediate, Direct Effects of Maintenance Activities of Flood Control Reservoirs

An evaluation of direct effects of maintenance activities at these flood control reservoirs is presented in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). No changes are planned for facilities or operation of these flood control reservoirs, future effects due to maintenance activities should be similar to the baseline condition *Interim Report 5*.

Maintenance activities would include silt removal and removal of noxious pondweeds. Silt, debris, and vegetation removal would also be performed at the inlets and outfalls to the reservoirs.

Sediment and weed removal from flood control reservoirs would not increase turbidity or cause downstream sedimentation because there is no flow from the work area. Listed fish species would not be injured during maintenance activities because there are no anadromous runs of salmonids past the structures on Brush, Paulin, Matanzas, or Spring creeks. Salmonids trapped in Spring Lake would be lost to the anadromous population, and this effect was evaluated separately.

When the large, shallow Spring Lake is drained for maintenance work, it has the potential to increase water temperatures in Santa Rosa Creek. It may take 4 to 6 weeks to drain the reservoir, and this activity may occur about once every 12 years. Spring Lake would be drained as early as possible in the spring while water temperatures are cooler and creek flows are higher to avoid increasing summer water temperatures above threshold limits for salmonids.

In general, maintenance activities would not directly affect salmonids. While there would likely be an increase in water temperature in Santa Rosa Creek when Spring Lake is drained, this increase is unlikely to exceed thresholds that are suitable for salmonid rearing. The water would be released as early as possible in the spring when water temperatures are still cool.

Evaluation of Effects on Fish and Long-Term Habitat Alteration from Passive Operation of Flood Control Reservoirs

A detailed evaluation of the effects on listed species and long-term habitat alterations that result from passive operation of the flood control reservoirs and criteria and effects scoring are presented in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). No changes to passive operation of the flood control reservoirs are planned so future effects on the listed salmonid species and their habitat would be similar to those described in *Interim Report 5*.

Attenuation of peak floods is not likely to negatively affect downstream channel geomorphology through alteration of channel maintenance flows. Only a small drainage area is captured by the Brush Creek and Piner Reservoir, so that peak floods are probably not significantly altered and resulting downstream effects are not likely to be significant. Matanzas Creek Reservoir generally fills and spills after mid-December, so channel maintenance flow events would pass to the natural downstream reach during the winter period. In Santa Rosa Creek most of the channel downstream of Spring Lake has been altered for flood control and attenuation of peak flows from storage in Spring Lake does not negatively affect the geomorphology of the creek.

There is no outflow from these reservoirs during the summer so summer water temperatures would not be increased in the downstream reaches of the creeks.

When the instream reservoirs (Matanzas, Brush, and Piner) refill in the rainy season, downstream flows would be reduced. Brush and Piner reservoirs are small and are located fairly high in the watershed, so the effect to downstream habitat is not expected to be significant. Matanzas Creek reservoir has a larger capacity and affects a larger drainage area. It generally begins to spill in mid-December, so flows during the first half of the coho upstream migration period (November through January) and the early portion of the coho salmon spawning season (December through mid-February) may be affected. This affects half of the upstream migration period and the early portion (20 percent) of the coho salmon spawning season. Therefore, the risk to the population is low.

Sediment and large woody debris retention on Brush Creek, Piner Reservoir, and the diversion on Spring Creek are low because these facilities are small, so effects to downstream habitat would likely be minimal. The sediments removed from the Spring Lake diversion on Santa Rosa Creek usually contain finer rather than coarser sediments, and the diversion of some small amounts of gravel is not likely to affect the availability of spawning habitat in this reach of Santa Rosa Creek. Large woody debris is only rarely trapped in Spring Lake, and if it is removed, it is likely to be used in revetment work elsewhere. Large woody debris has not been removed from Matanzas Creek Reservoir in the past so it appears that it is generally not recruited there.

The capacity of Matanzas Creek Reservoir is larger, so retention of spawning gravel in the reservoir may affect downstream spawning habitat. Spawning habitat is also limited by other issues related to the geomorphology of the channel. Portions of Matanzas Creek (downstream of E Street) have been channelized and levied, which reduces the habitat value of these reaches. A 1997 CDFG stream inventory survey conducted upstream of E Street (CDFG 2001a) indicated that the best spawning habitat exists in the lower portion of Matanzas Creek, but sediment transported downstream in the winter impacts potentially good-quality spawning gravel. Little riffle habitat for spawning was found, and what does exist was unsuitable due to high gravel embeddedness. The CDFG report concluded that measures to reduce fine sediment input should be implemented, but did not cite lack of spawning gravel as an issue. Therefore, while some spawning gravel may be retained in the reservoir, the risk to the populations of listed fish species from gravel retention is low.

Spring Lake is a large, shallow lake that provides habitat for warmwater fish species that prey on salmonids. Largemouth bass and crappie have been caught during fish rescues conducted in Spring Lake (S. Chase, SCWA, pers. comm. 2003a). When Spring Lake is dewatered for maintenance, a screen prevents the release of predators from the lake to Santa Rosa Creek. Piscivorous fish could escape from Spring Lake by traveling through the stand pipe that drains when the lake elevation becomes high during storm-flow events. Escapees from Spring Lake may contribute to the local population of predators in downstream areas. Populations of largemouth bass are already established in the Russian River and possibly in the Laguna de Santa Rosa, so introduction of largemouth bass from Spring Lake would not introduce a new risk to Santa Rosa Creek. However, habitat in

Santa Rosa Creek is not generally favorable for largemouth bass (S. Chase, SCWA, pers. comm. 2003a).

Data collected in 1999 in Santa Rosa Creek a short distance upstream of Spring Lake indicate that this reach of Santa Rosa has cool summer water temperatures (mean monthly temperatures of 15.7ºC to 17.5ºC in June through September) (SCWA 1999d). Mean monthly water temperatures in Santa Rosa Creek further downstream of the reservoir (near the US 101 Bridge) were only about 1ºC higher. These data indicate that summer water temperatures in these reaches are likely to favor salmonids over the warmwater fish community.

A small, chlorinated swimming lagoon is drained or pumped to Spring Lake when the swimming season is over. However, chlorine dissipates as it passes through the water cannon in the lagoon and would be diluted once the water enters Spring Lake. Therefore, chlorine levels in water discharged from Spring Lake would be very low.

The most significant effect of the flood control reservoirs would continue to be entrapment of anadromous salmonids into Spring Lake. Storm events with flows high enough to flow to Spring Lake generally occur in January and February, but after March storm events this high are less frequent. Juvenile steelhead or coho salmon could be trapped during outmigration (February through mid-May). Because good quality spawning and rearing habitat occurs upstream of the diversion, it is expected that some coho salmon and steelhead may be trapped. Fish sampling in Santa Rosa Creek (Cook and Manning 2002) found no coho salmon, so currently the risk to coho salmon is very low. The study documented the presence of steelhead in reaches near Spring Lake and in the headwaters. The predominant age class was young-of-the-year, with a few older fish present. Age 1 and older fish are smolt-sized and most likely to move downstream during high flows. Although fry may also be carried downstream during high flow events, fry emergence does not begin until March. Furthermore, fry that are displaced so early in the incubation and emergence period are susceptible to mortality due to high flows. Therefore fry are far less likely to be entrained into Spring Lake.

Only about one storm event in a year would be high enough for water to spill to Spring Lake, for a few days in most years, and chances are that many of these events would occur prior to the steelhead downstream migration period. The risk to the population of steelhead is low because only a fraction of the smolt-sized fish that would migrate during a single storm would be affected, only one storm per year results in flows high enough to divert to Spring Lake, and the overlap between the juvenile salmonid migration period and the period of time water is most likely to spill to Spring Lake is not long.

5.4.2.5 Bank Stabilization in Central Sonoma Watershed Project and Mark West Creek Watershed

Maintenance activities are performed on levees and bank stabilization structures on waterways in the Santa Rosa urban area. Maintenance of riprap is often needed in various channels in the Mark West Creek watershed (B. Oller, SCWA, pers. comm. 2000). A channel alignment project was completed at the confluence of Hinebaugh and Wilfred creeks. This was an old flood control project and this kind of project is not planned for the future. When riprap is repaired, Methods 5, 6, and/or 7 may be used. Sediment containment evaluation scores for these methods are given in Table 5-45 (see description of methods in Section 5.4.3.1). Opportunity for injury evaluation scores are given in Table 5-46.

The work area would be isolated with a barrier when it affects a wetted portion of the stream to minimize direct injury to fish. Effective sediment control BMPs would be employed to limit input of sediment from work on streambanks and instream work. Because the work would be generally performed on eroding banks, this bank stabilization measure would likely to decrease sediment input to the stream and would not have large effects on existing native riparian vegetation. However, hard-armoring techniques such as riprap can prevent the establishment of a native riparian corridor over the long term, reducing benefits to salmonid habitat, like riparian cover and cooler water temperatures. SCWA has developed a set of BMPs and other guidelines to limit the amount of hard-armoring in natural waterways associated with bank stabilization work. These guidelines give priority to the use of bioengineering and revegetation whenever feasible to prevent the loss of riparian habitat and to protect aquatic habitat for listed species.

Table 5-45 Sediment Containment Evaluation Scores for Bank Stabilization and Structure Maintenance and Repair Practices

Category Score	Evaluation Category	Method Score
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	9,10,12,16
4	Clean bypass or similar method used.	15
3	Effective instream sediment control (e.g., berm/fence).	5,6,7,8,11
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	5,6,7,10, 11,16
4	Limited disturbance with effective erosion control measures.	9,12,15
3	Moderate to high level of disturbance with effective erosion control measures.	8
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

Table 5-46 Opportunity for Injury Evaluation Scores for Bank Stabilization and Structure Maintenance and Repair Practices

Category Score	Evaluation Category	Method Score
5	Project area is above the high-flow WSE defined by the 1.5-year bankfull event and/or above the tops of bars, and requires no isolation from flow.	7,10,16
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	12
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	5,6,8,11,15
1	Appropriate BMPs are not applied.	

5.4.3 Bank Stabilization in the Russian River and Dry Creek

Channel improvements were built to control streambank erosion after the Warm Springs Dam Project and Coyote Valley Dam Project regulated flows in Dry Creek and the upper mainstem Russian River. The USACE inspects these sites and SCWA and the MCRRFCD maintain them in Sonoma and Mendocino counties, respectively. SCWA and MCRRFCD also inspect non-project levees (Public Law 84-99 sites) and property owners are informed of needed repairs.

USACE guidelines for the maintenance activities downstream of Warm Spring and Coyote Valley dams are contained in USACE Flood Control manuals (USACE 1965a, 1965b, 1991). USACE, in coordination with NOAA Fisheries and CDFG, would review the sediment and vegetation control obligations contained in the USACE Flood Control manuals and modify them to minimize the effects of these activities on listed fish species.

This section evaluates effects related to maintenance of channel improvement projects. It also assesses vegetation removal and gravel-bar grading to control bank erosion in the mainstem of the Russian River.

5.4.3.1 Warm Springs and Coyote Valley Dam Projects on Dry Creek and Russian River

Maintenance of Bank Stabilization Structures and Levees

Current bank stabilization activities involve maintenance of these channel structures. No new structures are planned. Several types of bank stabilization projects were implemented on Dry Creek and the Russian River:

- Anchored steel jacks
- Flexible fence training structures
- Wire mesh and gravel revetments

- Pervious erosion check dams
- Rock bank
- Board fencing
- Erosion control sills
- Concrete weir

Some structures have been covered with soil, have well-established vegetation, and, therefore, do not require maintenance beyond inspections. If, during annual inspections, the USACE finds erosion that could undermine levees, SCWA makes repairs. Two types of maintenance activities are performed: 1) bank repair (earth banks) and 2) structure maintenance/repair.

Methods

Standardized maintenance methods and BMPs have been developed in conjunction with the Bay Area Storm Water Management Agencies Association (BASMAA) to minimize negative environmental effects (SCWA 1996b). (Method numbers not discussed in this section apply to sediment and debris removal and to vegetation control.)

Method 5: A dump truck, or excavator with an extended arm, is used to repair rock riprap or place rock in areas of slope undercutting, scour hole or bank slope erosion. Rock is dumped directly on the bank from a dump truck. If the face of the slope has eroded, the excavator digs a 2- to 3-foot-deep trench at the toe of the bank for the width of the eroded area. The excavating equipment places 2 to 3 feet of rock into the toe, and rock riprap is placed up the bank from the toe. Smaller rock may be dumped to fill voids in the larger riprap.

Method 6 is used to repair large and long erosion areas. In addition to activities in Method 5, the excavating equipment may fill the area farthest from the channel slope with native soil or road-base shale and then compact the area. Rock riprap is placed up the band from the toe. Smaller rock may be dumped to fill the voids.

Method 7: Erosion areas around culverts are repaired by excavating the trench containing the culvert with excavating equipment, dumping sand, or native soil on the bank, and then using the excavating equipment to place the material into the trench. Portable compactors compact the fill. Six inches of road base is dumped into the excavated area and compacted using a roller/compactor.

Method 8: Shaping may be done in constructed channels, but not on natural waterways. A dozer with a blade is used to align flow direction of the creek or channel and to protect banks or restore erosion damage. The dozer is operated across or up and down the bank, using the blade and tracks to compact the soil.

Method 9: Dirt or rock access roads are repaired by dumping dirt or rock from a dump truck over the areas of road, spreading the material with a grader, and using a roller/compactor to compact the surface.

Method 10: Undercut pipe outfalls are repaired by replacing rock in scour holes below the pipe and reshaping the channel to direct flows away from the affected areas. If the erosion is deep, Method 6 is applied.

Method 11: Grouted rock is repaired by clearing the area of broken or damaged material with an excavator with an extended arm or a backhoe operated from the service road. Bank disturbance is kept to a minimum because equipment is not operated on the bank. Deeply eroded areas are repaired if necessary with Method 6. Rock riprap is placed on the bank of the stream channel bottom with Method 5 and grouted with ready-mix concrete from a shoot or a concrete pumper.

Method 12: Minor underlining of a lined channel is repaired by accessing the area behind the lining from the top of the bank using hand tools or a backhoe to open a small access. A concrete/sand slurry ready mix would be distributed using a shoot or a concrete pumper.

Method 13: Major undermining repair would be contracted out. Historically, significant undermining has not occurred.

Method 15: When drop structures or check dams are repaired, water is diverted around the affected area. Isolation from flow would minimize sediment input and direct injury to fish. If the diversion is large, a dozer with a blade brings in or moves on-site material for construction of a berm or diversion dam.

Method 16: Three to four person crews repair chainlink, field and barbed wire fences, and pipe stepover and smaller swing gates. Fence parts, whole fences or gates may be repaired or replaced. The equipment used may include hand tools, welder, fence stretcher, winch etc. Smaller pipe stepover and swing gates are fabricated on-site or at SCWA's shop.

These practices and their potential effects on listed species and their habitat were more fully evaluated in *Interim Report 5: Channel Maintenance* (ENTRIX, Inc. 2001b). Each method was evaluated for direct effects on critical habitat or injury to fish during the maintenance activities (Table 5-45 and 5-46).

In general, the greatest potential, direct, short-term effects to fish or their habitat could occur from repair of eroded banks (Methods 5 and 6), and shaping of constructed channels (Method 8), particularly if work is done near the toe of the channel. Because a barrier would be used to control potential downstream sedimentation, a score of 3 is applied for these methods (Table 5-45). No bypass or fish rescue/escape would be provided, so there is a potential for injury to fish, as reflected by a score of 2 in Table 5-46. However, heavy equipment would not generally be operated in the streambed, so the overall risk is low. Other methods may have potential, localized direct effects that are smaller in scale.

Long-term effects from these projects may include decreased erosion when banks or landslides are stabilized. Instream cover may increase if rocks fall into the stream. The extent of these effects depends on how much work is required in the streams or river, and are discussed in the following sections. The extent of these effects also depends on the condition of the riparian corridor and the streambed, because poor habitat conditions may be improved.

Warm Springs Dam Channel Improvement Sites (Dry Creek)

SCWA maintains 15 federal sites in Dry Creek. One nonfederal site in Dry Creek is inspected by SCWA. To ensure the flood control works remain eligible for rehabilitation under Public Law 84-99, a nonfederal project must meet the minimum USACE requirements before any request for assistance can be provided. It is required that the work be performed prior to the flood season or within 6 months of the inspections.

A biennial post-flood season inspection of the Dry Creek Channel Improvement Project was conducted on July 26-27, 1999 by the USACE. Table 5-47 provides information about the 15 bank stabilization structures (federal sites) located on Dry Creek, as noted in the 1999 USACE inspection. Rock bank structures are usually located on one bank. The 1999 USACE inspection of the 15 federal sites gives an idea of the amount and type of work that is generally needed.

It was noted that in all bank protection sites, vegetation should be trimmed to allow inspection. At the board fence sites, large trees and other vegetation would begin to damage the fence if not trimmed or removed, and large trees and other vegetation are beginning to choke the channel. Tree removal and regrouting were recommended for concrete sills. Tree trimming and/or removal at the board fence sites would reduce the amount of woody debris that may otherwise have been available in sites 3, 8, and 12.

Table 5-47 Channel Improvement Sites on Dry Creek

Site	Type	Length (ft)	Summary of Comments on Repairs needed
1	Rock Bank	600	Heavy vegetation prevented close inspection, but probably helps hold toe in place. No apparent scour.
2	Rock Bank	750	Heavy vegetation above the toe should be trimmed to allow inspection.
3	Board Fence	700	Some fallen trees in the creek should be cleared. Large trees will begin to damage the fence if not trimmed or removed. Fence and posts still in good condition.
4	Rock Bank	200	Only upper rock is accessible. Vegetation needs to be trimmed or removed above toe of rock.
5	Concrete Weir		Good condition.
6	Rock Bank	450	Weir in good condition. Trees in the channel have been trimmed. The downstream grouted rock is undercut. The channel between the weirs is steep and eroded, and further bank protection should be considered.
7	Board Fence	900	Only the upper rock is accessible due to heavy vegetation.
8	Rock Bank	480	No land access is available. Large trees are falling and should be cut before the fence is damaged.
9	Concrete Weir		Site in good condition. Heavy brush on the right side of the channel should be cleared or trimmed to maintain the channel capacity.

Table 5-47 Channel Improvement Sites on Dry Creek (Continued)

Site	Type	Length (ft)	Summary of Comments on Repairs needed
10	½ Rock Sill and Bank		Sill is probably buried and the rock protection in good condition. Dirt has apparently been moved over the sill apron by the landowner, making it very hard to locate.
11	Rock Bank	200	The rock is in place, mostly covered with low brush.
12	Concrete Sill		There is a large sand bar with large trees in the center of the channel, downstream from the fish ladders. Trees should be removed or trimmed. Grout is wearing out and should be redone. Trash racks need cleaning.
13	Concrete Sill		Driftwood should be removed. Rocks are coming loose from grout, which should be redone.
14	Concrete Sill		Several small boils are coming through the sill, and rocks are coming loose. Needs regrouting to attach rock and fill boil paths.
15	Rock Bank	500	Heavy vegetation should be trimmed above the toe. There is some sediment aggradation in the lower reaches of the project, mainly upstream from the sills.

Grouted areas that need repair would require Method 5. As the channel between weirs at site 6 was steep and eroded, it was recommended that further bank protection should be considered. The largest effects would likely occur where bank protection and undercuts need repair, as in site 6, where Methods 5 or 6 are required (see *Interim Report 5: Channel Maintenance* for a detailed assessment of effects from these practices). Methods 5 and 6 could introduce turbidity and sediment to Dry Creek during work on the toe of the stream channel, but a barrier used during construction would reduce suspended sediment concentrations. There is a small risk of injury to fish because no bypass, rescue, or escape would be provided, but limited, if any, instream work would be required.

No new structures are proposed in Dry Creek. Activities are limited to maintenance of existing structures, and no additional vegetation maintenance is proposed in Dry Creek. Therefore, effects would be generally limited to small-scale effects related to sediment input to the creek and some small amount of vegetation removal. Effective BMPs reduce the risk of short-term effects. Therefore, both short-term, direct effects to fish and long-term habitat effects would be low.

Coyote Valley Dam Channel Improvement Sites (Russian River)

The bank stabilization sites in the federal portions of the Russian River channel improvement project consist primarily of levees, anchored jacks, and riprap banks. Additionally, flexible fencing projects were installed in some places. Table 5-48 is a list of sites that were inspected in September 2000 (USACE 2000). Sites are identified by the river mile location of the downstream end and indicate right or left bank looking downstream. A previous inspection report categorized numerous sites as destroyed, functioning, or buried, and a list of these 21 sites was presented to be reinspected. The amount of work recommended on these sites is fairly typical of what is recommended each year.

Table 5-48 Field Inspection of 21 Sites in the Federal Portion of the Russian River Channel Improvement Project (RM 42.4 to RM 61.3) (September 2000)

Site[1]	Summary of Comments on Repairs needed
42.4R	Heavy vegetation on a stable bank. Some jacks visible. Cable not anchored downstream.
43.5R	Stable bench, with jacks about 1/2 buried in heavy vegetation along a tree line.
46.7R	High exposed bench with some rock protection. Large wooded island in the riverbed. No jacks or fence could be found. Site is buried, hidden in heavy vegetation on the island, or gone.
49.2R	Bank stable, with heavy vegetation. Jacks could not be seen.
50.8R	Jacks probably buried under a stable bench with heavy vegetation.
53.1R	High stable bench, but the only jacks visible appear damaged, separate parts in a ditch.
53.9R	There is a bench and heavy vegetation. Jacks are buried or gone.
54.4R	There is a high bench with heavy vegetation. The site is buried in the bench or gone.
56.5R	The bench has been cleared. Jacks are buried or gone.
57.7R	Jacks are about 2/3 buried on a stable bench. Last year the line was found to be cut for a road access to the river.
61.1R	Bank appears stable. Only rock could be found. Jacks may be under the rock.
46.8L	Stable bank with heavy vegetation. No jacks found.
48.7L	Bank appears stable. Jacks in heavy vegetation at upstream end. No jacks for at least the downstream 300 feet, except for a pile at the downstream end. There is rock protection on the downstream 300 feet.
50.0L	Bank appears stable. Site has jacks below rock protection along much of the bank.
50.3L	Entire bank appears stable. There are some jacks upstream, some buried, some loose. The downstream slope has rock protection.
50.6L	Not a bank stabilization site. Loose jacks noticed on the riverbank.
51.0L	Jacks are in place along a stable bench with a levee on the water side.
51.3L	Bank stabilized by a tree line. Many pieces of jack, cable and rod indicate the jack line has been destroyed and need not be inspected in the future.
52.9L	High bench may conceal the jack line. No jacks found along the bank, one was in the river channel.
57.8L	Downstream jacks are damaged, unburied, and not anchored. The upstream 1/2 of the jack line is in heavy vegetation on a stable bank.
58.9L	Bank looks stable. Some jacks visible downstream, some found further upstream with approximately 2 feet protruding last year. Some are probably missing.
61.3L	Bench looks very stable. Site has a fence upstream and jacks downstream in heavy vegetation. Downstream jacks are at the water line.

[1] "R" and "L" after the River Mile refer to right or left bank, looking downstream.

Most of these sites are in stable condition and do not require work in the near future. Based on this inspection, the USACE recommended various repairs or replacement of some of these structures. These recommendations are presented in detail in *Interim Report 5: Channel Maintenance.* The USACE also recommended that a vegetation management program be implemented to reduce blockage of the river channel and increase access for maintenance and inspection of the banks, and that all loose, nonfunctional jacks be removed from the project reaches.

Because most of these sites are in stable condition, it is not expected that there would be substantial short-term or long-term effects from maintenance of these sites. However, in combination, the federal and nonfederal obligations to maintain levees and bank erosion control structures on the Russian River could have a substantial habitat altering effect.

This effect would be primarily related to a reduction in the extent of riparian corridor by tree removal, trimming, and placing riprap on streambanks. This would reduce available shading and cover. Benefits related to reduced sediment input due to reduction of streambank erosion are also likely to occur.

Nonfederal Portion of the Russian River Channel Improvement Project

The USACE, SCWA, and MCRRFCD would continue to inspect nonfederal channel improvement projects related to Public Law 84-99 in the Russian River and one levee in Dry Creek. If repairs were needed, the property owner and USACE would be notified, and the property owner would be responsible for needed repairs. The effects of channel maintenance activities for nonfederal projects are evaluated as interdependent effects in Section 7.

5.4.3.2 Gravel Bar Grading and Vegetation Maintenance for Bank Stabilization in the Russian River

In the mainstem Russian River, gravel bar grading and vegetation maintenance would continue to be conducted by two different agencies, the MCRRFCD and SCWA, each in their respective counties, to control bank erosion.

Sediment maintenance work would consist of grading gravel bars and creating overflow channels during the dry summer season. This activity would be linked to vegetation maintenance practices. Sediments would be redistributed in the channel primarily to create overflow channels through existing bars to direct water flow during high flow events and to prevent bank erosion. Vegetation removal would be more limited in scope than for baseline conditions.

SCWA would maintain over a 22-mile reach between RM 41 near Cloverdale to RM 63, near the Mendocino County line. MCRRFCD also would continue to excavate and grade sediments at targeted sites in over a 36-mile reach of the Russian River. MCRRFCD would survey one-third of the 36-mile reach (12 miles) annually. Site-specific areas where maintenance is needed would be identified for work implementation. CDFG staff would continue to participate in site visits and consult on site selection. Two or three areas with potential for “blowouts” of streambeds or banks may be worked on annually in each county, with a maximum of four sites in a year per county. These sites selected for maintenance work generally range in size from 10 to 300 feet in length.

Gravel Bar Grading

Potential effects of gravel bar grading operations could include direct injury to fish and immediate, direct effects to habitat. Indirect effects to habitat could include an increase in sediment to the stream and long-term alterations to migration, and spawning and rearing habitat.

Direct Effects to Fish

Gravel bar grading and sediment removal activities have the potential to injure or kill fish. However, because work would be conducted on gravel bars during the dry season and away from the wetted channel, there would not likely be a risk of direct effects on fish. The work would be conducted between July 1 and October 1 to avoid spawning and incubation periods. The only species/life-history stage that may be present on the Russian River during gravel bar grading or vegetation removal work is rearing juvenile steelhead (low-flow summer period).

SCWA and MCRRFCD biologists assess habitat conditions prior to sediment removal to ensure that listed fish species are not likely to be in the maintenance area. Because work would be conducted outside and away from the wetted channel, the work requires no isolation from flow and the score is 4 (Table 5-49).

Work would take place on dry gravel bars during the low-flow season, and would not require re-routing streamflow in the low-flow channel. Therefore score of 4 was given for instream sediment containment (Table 5-50). Easy access to the site from existing service roads at the top of bank may not be possible along the Russian River, and occasionally access roads may have to be installed. However, SCWA and MCRRFCD employ upslope sediment control measures such as silt fences when performing the work, so a score of 3 is given, indicating a moderate- to high-level of disturbance with effective erosion control measures.

Table 5-49 Opportunity for Injury Evaluation Scores for Gravel Bar Grading in the Russian River

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	St
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*St = steelhead

Table 5-50 Sediment Containment Evaluation Criteria

Category Score*	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	St
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	St
2	Action likely to increase sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

*St = steelhead

Long-Term Habitat Changes

Gravel bar grading and vegetation removal may result in alterations to salmonid spawning, rearing, and migration habitat. The Upper and Middle Russian River contain steelhead and Chinook salmon migration, spawning and rearing habitat, and coho salmon use the Middle Reach as migration corridors. Alterations to mainstem habitat are most likely to affect Chinook salmon spawning and rearing because the Upper Russian River may contain primary habitat for those life-history stages.

Potential effects include:

- Gravel bar grading and re-alignment in the Russian River is likely to affect the geomorphology of the channel. Vegetation with roots that stabilize the channel may be moved. By preventing stable bar development, the channel becomes straightened and sinuosity decreases. Decreased sinuosity reduces bank erosion, but also reduces the opportunity for pool development by limiting scour on the outside of meander bends. In addition, gravel bar grading generally results in a flatter streambed, reducing the hydraulic diversity and associated aquatic habitat diversity represented in the channel. This lack of hydraulic diversity probably includes reduced availability of high-flow refuge habitat due to limited bedform topography as bars are regularly regraded. In addition, maintenance activities such as re-aligning the river channel to prevent bank erosion may have other consequences, including reducing hydraulic and associated habitat complexity.

- Gravel bar grading is closely interrelated with removal of riparian vegetation growing on the bars. A 25-foot buffer strip would provide shade and cover along the low-flow channel and help protect summer water temperatures.
- Disturbance of sediments within the channel during the low-flow season, as well as removal of vegetation on channel bars, may potentially result in increased mobilization of fine sediments during the high flow season. This could result in sedimentation of spawning gravel and sedimentation of rearing habitat substrates both within the immediate area where work was done and in downstream areas. Sedimentation of aquatic habitat may also affect aquatic insect production that forms the food base for juvenile salmonids. Loss of spawning gravel is not expected to occur because, in general, sediments are not permanently removed from the river. (Spawning gravel removed from the Lower Russian River may be relocated to Dry Creek where potential spawning activity may be higher.)

Scoring criteria consistent with NOAA Fisheries guidelines for sediment removal (NOAA Fisheries 2003b), are applied for the height of sediment to be removed from gravel bars. Most bars along the river are greater than 3 feet in height above the low-flow water surface elevation. By reducing the bar height to 1.5 feet above the low-flow water surface, a bar that begins with a total height of 3 feet would thereby be reduced by 50 percent. Bars taller than 3 feet would be reduced by greater than 50 percent, assuming that they are graded to a final elevation of 1.5 feet above the low-flow water surface. Therefore, scores would range between 1 and 2, indicating that this work would degrade fish habitat (Table 5-51).

Table 5-51 Evaluation for Gravel Bar Grading in the Russian River

Category Score	Evaluation Category	Current Operations Score*
5	No sediment removal or grading.	
4	<25% of the bar height is removed.	
3	25% to 50% of the bar height is removed.	
2	>50% to 75% of the bar height is removed.	Co, St, Ch
1	>75% of the bar height is removed.	Co, St, Ch

Co = coho salmon, St = steelhead, Ch = Chinook salmon

Under the proposed project, the scope of work would be more limited than under baseline conditions. No more than four bars in each county (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year. The length of any one site would not exceed approximately 1,000 feet, or a single bar length. The areas that would receive gravel bar grading and vegetation maintenance would be scheduled so that bars are worked on in rotation over a course of 3 to 5 years. This way, some bars would always provide high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) in any given year. Protocols would be implemented to preserve a buffer zone, grade the channel to minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site in a year, the limitations under the proposed project are designed to ensure that sufficient, good-quality habitat remains in the mainstem over time.

Vegetation Maintenance

On the mainstem Russian River, SCWA vegetation maintenance would extend from approximately RM 41 near Cloverdale to RM 63, near the Mendocino County line. Channel clearing would include removal of serious obstructions, including trees, brush, and snags. This work may be done in conjunction with gravel bar grading operations. Evaluation criteria are used to assess the potential effect on salmonids and habitat of various percentages of vegetation removed from the Russian River.

Alternative measures would be pursued where feasible, such as the utilization of bio-engineering practices to stabilize banks, tree planting to add bank stability and reduce understory growth, offset levees to increase floodplain, or floodplain level culverts to increase floodplain draining at culvert crossings.

Selective vegetation removal by hand limits streambed and streambank disturbance. When vegetation is removed from the stream channel bottom, there is a reduction in the amount of cover available in the stream and a loss of winter high flow refugia. Therefore, this practice would be restricted to when there is an unacceptable threat from a 100-year flood event or where a decrease in bank stabilization threatens a manmade structure. Native trees growing along streambanks have been allowed to become established and this has increased riparian corridor width. This practice would continue.

No recent estimate of vegetation removal requirements have been made by SCWA for the Russian River; however, previous maintenance included removal of vegetation from approximately a 250-foot- to 400-foot-wide section of channel (B. Oller, SCWA, pers. comm. 2000). On the mainstem Russian River in the Alexander Valley, channel widths generally range from approximately 200 feet to 800 feet. Upstream of Alexander Valley, channel widths are narrower, approximately 200 feet to 500 feet. Given the need to remove vegetation from an estimated 250-foot to 400-foot width of the Russian River, this would result in loss of 40 percent to 100 percent of the riparian vegetation within the channel at locations where the vegetation maintenance occurs. Because steelhead and Chinook salmon rearing and spawning may occur in the mainstem, the score is 1 for these species (Table 5-52).

In Mendocino County, maintenance work consists of removing willows, grading bars, and creating overflow channels, primarily to reduce the potential for streambank erosion during high flows. It is estimated that more than 50 percent of the vegetation in the channel cross sectional area is typically removed and/or re-distributed against the streambank. This practice would continue. Therefore, the score for MCRRFCD maintenance practices is a 1 (Table 5-52). Up to four sites may be regularly maintained.

Table 5-52 Vegetation Control Scores for the Russian River — Sonoma and Mendocino Counties

Category Score	Evaluation Criteria Category	Score
5	No vegetation removal except "spot" treatment, or removal of only non-native species.	
4	<10% removal.	
3	>10% to <25% reduction in vegetation.	
2	>25% to <50% reduction in vegetation.	
1	>50% reduction in vegetation.	St, Ch

*St = Steelhead, Ch = Chinook salmon

Vegetation removal, combined with gravel bar grading, has the potential to result in habitat alterations, including changes in channel geomorphology and sedimentation of aquatic habitat. The removal of riparian vegetation on bars likely reduces the availability of high-flow refugia and generally decreases hydraulic and associated aquatic habitat diversity, and it may take years for vegetation to reestablish. In addition, bar accretion is minimized when velocity-retarding vegetation is removed, thereby reducing sites available for sediment deposition and storage. Inhibiting bar development most likely results in reduced channel sinuosity. This change in channel geomorphology tends to reduce the formation of pools and also contributes to the overall lack of hydraulic and aquatic habitat diversity.

SMI stream habitat typing data show summer habitat conditions throughout the Alexander Valley are typical of a simplified channel (Jensen and Halligan 1999, cited in NMFS 2002). There are low shelter ratings, low occurrence of backwater habitats, low values of vegetated area on banks, and other indications of poor velocity refuge conditions. Therefore, further loss of these shelter components with the proposed project may contribute to further degradation of habitat in portions of the mainstem.

Sediments disturbed during the low-flow season may be mobilized at the onset of the rainy season. Mobilization of fine sediments from the streambed over substantial lengths of the Russian River could collectively have an effect on steelhead and Chinook spawning and rearing habitat. Because the first flows of the rainy season are most likely to mobilize recently disturbed sediments, the effect is likely to be greatest for Chinook because they spawn occurs earlier and egg incubation occurs over a longer period of time.

Vegetation removal for bank erosion control has the potential to cumulatively result in substantial habitat alterations. Protocols would be implemented under the proposed project to reduce the cumulative effects of the work. The work would be limited so that vegetation would only be removed if necessary to protect against severe bank erosion, or to protect levees, infrastructure, or private property. Buffer zones would be maintained to protect the existing thalweg of the channel. Vegetation removal would be scheduled so that bars are worked on in rotation, thereby leaving some bars that would always have willows that provide high-flow refuge areas for salmonids. Although effects to salmonid habitat would be expected to occur, the limitations under the proposed project would be implemented to ensure that sufficient habitat remains for listed fish species.

Synthesis of Effects of Gravel Bar Grading and Vegetation Maintenance for Streambank Stabilization

Immediate, direct effects to fish and sedimentation to aquatic habitat are likely to be minimal or nonexistent. The work would be scheduled to avoid spawning an incubation periods. Steelhead may rear in the mainstem during the summer, particularly in the upper mainstem, but are not likely to be substantially affected by the work.

Gravel bar grading and vegetation maintenance could have long-term effects to salmonid habitat. Coho salmon utilize the mainstem primarily as a migration corridor, and steelhead and Chinook salmon utilize the mainstem for spawning, rearing, and migration.

In the past, much of the mainstem of the Russian River has received periodic maintenance, and the potential to substantially alter habitat was great. Under the proposed project, these activities would be limited. No more than four bars in each county (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year and the length of any one site would be limited. Gravel bar grading and vegetation removal would be scheduled in rotation so that high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) would be maintained. Protocols would be implemented to preserve a buffer zone, minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site on a 3- to 5-year rotation, the proposed project would ensure that sufficient, good quality habitat would remain in the mainstem over time.

Sites along the mainstem Russian River where frequent and/or extensive maintenance are required to prevent bank erosion would be identified. These areas would be assessed as candidates for bank stabilization projects. Implementation of these projects would be coordinated with NOAA Fisheries. Bioengineered structures would be used whenever possible and sites would be limited to not more than 1,000 feet of channel to avoid large segments of continuous hard-armoring from cumulatively developing. This may reduce the need for future gravel bar grading and vegetation maintenance within a site and preserve instream habitat features. However, the benefits would be weighed against the risk that future streambank erosion problems may appear upstream or downstream of the site. Therefore, depending on site-specific factors, it may be preferable to continue implementation of gravel bar grading on a regular basis.

5.4.4 Emergency Bank Stabilization in Natural Waterways

5.4.4.1 Sediment Maintenance in Natural Waterways

SCWA does not perform routine sediment removal activities in natural waterways. However, emergency sediment removal and bank stabilization work is occasionally required in natural waterways after a large storm event. These instances are usually brought to the attention of SCWA, when landowners request SCWA to remediate problems associated with reduced channel flood capacity. In the past, sediment excavation in natural waterways has almost always been related to landslides, bank failure, or erosion. This activity would continue.

It is estimated, based on past activities, that sediment removal in natural waterways would occur about once every 10 years (B. Oller, SCWA, pers. comm. 2000). The most recent sediment removal project in a natural channel occurred on Big Sulphur Creek in 1997. However, remedial sediment removal in natural waterways could be needed on almost any stream in the Russian River basin following storm events. Listed fish species may or may not be present in the stream where the work may be required. Habitat conditions may also be highly variable in these natural streams. Some standard BMPs would be applied to work in natural waterways. If possible, sediment excavation and bank stabilization would be performed when the stream is experiencing low-flow conditions; generally during the summer or fall months. Depending on the location, there may or may not be flow in the channel at the time of the sediment removal work. If the channel is not dry, then flows would be diverted, typically using earthen coffer dams, pea gravel or, if necessary, a clean bypass. A fish biologist would inspect the reach where dewatering must occur to allow in-channel work. Fish rescue would be provided, if necessary. Work would be performed using backhoes, excavators, and dump trucks, depending upon the site configuration and available access. BMPs for operating equipment in or near an active stream channel would be followed.

Direct Injury to Fish

Evaluation for sediment containment and opportunity for injury is presented in Tables 5-53 and 5-54. Since listed salmonid species may be present on a given stream at the time of the sediment excavation work, the scoring is applied to all three listed species. The scoring results are similar to that for the flood control channels, except that a score of 3 is given to the upslope sediment control component. Unlike the flood control channels, easy access to the site from existing service roads at the top of bank may not be available on a natural channel. However, SCWA would continue to employs upslope sediment control measures such as silt fences when performing sediment excavation work, so a score of 3 indicating a moderate to high level of disturbance with effective erosion control measures is given.

Table 5-53 Sediment Containment Evaluation Scores for Sediment Removal in Natural Waterways

Category Score	Evaluation Category	Current Operations Score*
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Co, St, Ch
2	Limited sediment control.	
1	No instream sediment control.	

Table 5-53 Sediment Containment Evaluation Scores for Sediment Removal in Natural Waterways (Continued)

Category Score	Evaluation Category	Current Operations Score*
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	Co, St, Ch
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Table 5-54 Opportunity for Injury Evaluation Scores for Sediment Removal in Natural Waterways

Category Score	Evaluation Category	Current Operations Score*
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of gravel bars and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Co, St, Ch
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Sediment removal and channel clearing activities have the potential to injure or kill fish. Fish that are temporarily displaced may be subjected to stress, increased competition or predation. SCWA biologists assess habitat conditions prior to sediment removal to ensure that listed fish species are not likely to be in the maintenance area. If listed salmonids are determined to be present, a barrier would be established to exclude fish from the area. Fish rescues would be performed, if necessary. Therefore, sediment removal activities and their potential to injure fish in natural stream channels receive a score of 3 (Table 5-54).

Long-Term Changes to Critical Habitat Associated with Sediment Removal and Bank Stabilization in Natural Waterways

Sediment removal activities in natural waterways occur on a very limited and infrequent basis. All past sediment removal activities were associated with large landslides or storm events that delivered large amounts of sediment to the channel. Sediment deposited in the channel reduces flood capacity and may damage infrastructure such as roads, bridges, homes, utilities, etc. The extent of sediment removal varies depending on the amount of sediment deposited in the channel and other channel characteristics at the site. For example, on Big Sulphur Creek in 1997, approximately 1,000 feet of channel was excavated and bank stabilization work was performed.

SCWA would continue to implement BMPs and other guidelines for planning and implementing sediment removal and bank stabilization work performed in natural waterways to protect listed species and to minimize the potential for significant habitat alterations.

Potential habitat altering effects that may occur due to sediment removal in natural waterways include loss of shade canopy and cover, and loss of hydraulic and associated habitat diversity. The potential for habitat-altering effects due to sediment maintenance and bank stabilization in natural waterways to populations of coho salmon, steelhead, and Chinook salmon is small. This is due to the infrequent need for maintenance activities in natural waterways, the prescriptions for limiting the size of any project to 1,000 feet, and the guidelines for incorporating bio-engineering, revegetation, and fish habitat elements into bank stabilization work.

5.4.5 Gravel Bar Grading in the Mirabel/Wohler Area

SCWA augments infiltration capacity for its water distribution system in the Mirabel and Wohler area by periodically scraping gravel bars in the river in the area of diversion to increase infiltration in the river. BMPs would be implemented to control sediment input and turbidity in the river (see Section 4.4.5). SCWA biologists would inspect the gravel bars prior to the maintenance activity to evaluate the need for silt fences and to identify environmentally sensitive areas. Furthermore, permanent vegetation would not removed.

5.4.5.1 Effects of Scraping Mirabel and Wohler Gravel Bars on Critical Habitat and Fish

Gravel bar grading operations have the potential to affect listed species directly through disturbance, injury, or degradation of habitat. Indirect effects can be related to sediment input into the stream and increased turbidity. The following evaluation of risk to fish related to scraping of gravel bars includes: 1) opportunity for direct injury to fish during gravel bar scraping activities, 2) critical habitat degradation from sediment input to the stream, and 3) opportunity for habitat disturbance and/or injury related to the magnitude of the activity. Potential effects to the geomorphology of the river channel are also discussed.

Although some salmonid spawning has been documented by SCWA biologists in this section of the Russian River, primary spawning habitat is not located here. Rearing may occur in the winter and spring, but summer water temperatures are too high in some years to support steelhead rearing. Gravel bar grading operations at the Mirabel Bar do not normally occur during peak spawning migrations, but may occur during juvenile outmigration. At the upstream sites, the opportunity for injury to migrating juvenile salmonids due to scraping activities is minimal, since scraping occurs outside of the wetted channel.

At the Mirabel Bar, gravel is scraped to a low level, creating a depression in which fish may become trapped. The gravel scraping activity normally occurs after the coho and Chinook salmon outmigration periods, although in some years it may occur during the later portion of the outmigration. There is a greater risk to steelhead juveniles, which are more likely to be present during gravel bar scraping activities. Fish rescue is provided for fish trapped at the Mirabel Bar. Fish rescues on June 24 and July 29, 1999 resulted in the capture of 797 fish, although none of the fish were salmonids. No salmonids were captured during fish sampling in September at the Mirabel Bar.

Table 5-55 provides current operations scores for the gravel scraping operations in relation to opportunity for injury at the gravel bars. The scores for the Wohler, Bridge, and McMurray bars are 4 because although streambed sediments are disturbed, gravel bar scraping is done outside of the wetted channel. The score at the Mirabel Bar is 3 because although the area is excavated below the low-flow water level, the project area is isolated from the stream, and fish rescue is provided.

Table 5-55 Opportunity for Injury Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	Wohler, Bridge, McMurray
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Mirabel
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

The gravel bar grading operations upstream of the inflatable dam are limited to areas outside the active low-flow channel. Therefore, no instream sediment control measures are necessary at the Wohler, Bridge, and McMurray bars.

At the Mirabel Bar, gravel is removed to an elevation below the low-flow water surface elevation of the river. Implementation of BMPs would reduce effects to listed fish species. A berm constructed to prevent water from flowing through the area would control sediment and sediment fences would prevent the input of sediment into the river. Disturbance of salmonid habitat would be limited by keeping operation of equipment to a minimum and heavy equipment activity in the active stream channel limited to moving equipment to and from the mid-channel gravel bars. The sediment removed from the streambeds (spoils at the Wohler and Mirabel areas) would be stored outside of the floodplain, so they would not contribute to sedimentation of downstream habitat.

Turbidity was monitored in 1999 during the gravel bar grading operation at the Mirabel Bar. Background turbidity levels above the bar measured 3.4 NTUs. During construction activities, the upstream and downstream ends of the gravel bar were closed from the river. The highest peak of turbidity was 4.2 NTUs and this event lasted less than 30 minutes. When the grading operation was completed, the outflow channel from the Mirabel Bar was breached at the downstream end of the gravel bar. Turbidity levels reached 37.6 (2 hours after breaching), but levels had declined to 7.3 NTUs after 3.5 hours, and 4.3 NTUs after 5.75 hours. While this turbidity spike was significant, the event was short and would not be expected to have had a significant effect on juvenile salmonids.

Because gravel bar scraping operations occur during a limited time, and BMPs are in place to minimize sediment input into the river, it is likely that gravel bar grading operations would have only very limited, short-term effects on turbidity levels during juvenile rearing or migration. Turbidity is monitored continuously at two sites (upstream and downstream of the bar grading operation) at the Mirabel Bar to determine project-related effects associated with increased turbidity levels.

Sediment control was scored for instream and upslope practices (Table 5-56). The instream component for the Wohler, Bridge, and McMurray bars scored a 5 because the project area is generally dry. Gravel bar grading operations at the Mirabel Bar scored a 3 because the berm generally provides effective instream sediment control. The upslope component was used to evaluate spoils storage. Because spoils are stored away from the channel and operation of equipment on the banks is kept to the minimum necessary, the upslope sediment control score is 4.

The magnitude of the activity is examined at the sites in relation to bankfull widths in the respective areas. The McMurray Bar is approximately 1,000 feet long and 75 feet wide, and the Bridge and Wohler bars are 500 feet long and 100 feet wide (Table 5-57). The Mirabel Bar is approximately 1,000 feet long and 200 feet wide. An estimate of bankfull width from aerial photographs is approximately 200 feet at Wohler and 300 feet at Mirabel.

Table 5-58 estimates the magnitude of the action based on bankfull widths where the gravel bar scraping takes place. There are two components. Lineal distance of the disturbance is rated a 5 for the Mirabel, Wohler, and Bridge bars and 4 for the McMurray bar because the length of the bars is approximately equal to 5 bankfull widths. The width of the activity for Mirabel, Wohler, and Bridge bars is rated as 2 and for McMurray Bar as 3. Scraping at the upstream gravel bars generally occurs outside of the wetted channel and is not as likely to have direct effects. Gravel bar grading in the Mirabel area, based on the moderate size of the wetted area affected, may have a larger effect.

Table 5-56 Sediment Containment Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	Wohler, Bridge, McMurray
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Mirabel
2	Limited sediment control.	
1	No sediment control.	
	Component 2: Upslope Sediment Control (Spoils Storage)	
5	No upslope disturbance, or increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	Wohler, Bridge, McMurray, Mirabel
3	Moderate to high level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion an uncontrolled sediment input to the channel or major changes in channel morphology.	

Table 5-57 Approximate Sizes of Gravel Bars

Gravel Bar	Length	Width	Bankfull Width	Lineal Distance in Bankfull Widths	Width of Activity (Percent of Bankfull Widths)
McMurray	1000	200	75	5	38%
Wohler	500	100	200	2.5	50%
Bridge	500	100	200	2.5	50%
Mirabel	1000	200	300	3.3	67%

Table 5-58 Magnitude of the Action Evaluation Scores for Gravel Bar Grading Upstream of Mirabel

Category Score	Evaluation Category	Current Operations Score
	Component 1: Lineal Distance Estimated in Bankfull Widths	
5	<5 bankfull widths	Mirabel, Wohler, Bridge
4	5-10	McMurray
3	10-20	
2	20-30	
1	> 30	
	Component 2: Activity Width as a Percent of Bankfull Widths	
5	<10 percent of bankfull width	
4	10-25%	
3	25-50%	McMurray
2	50-75%	Mirabel, Wohler, Bridge
1	75-100%	

Gravel removal has the potential to increase stranding of juvenile fish, and to affect the geomorphology of the river channel. When gravel bars are scraped to improve infiltration, the result is a flatter streambed. Improper grading of streambanks could create large, flat, shallow areas along the stream margin or large depressions along the stream margin that become dewatered at low flows. Juvenile fish that take refuge in these areas can be stranded when these areas become dewatered at low flows. After gravel bar grading operations are completed, SCWA contours gravel bars to an approximately 2 percent grade to reduce the potential for stranding.

Given the characteristics of the river in the area, gravel bar scraping activities are not likely to significantly change the geomorphology of the channel and therefore habitat types are not likely to be different. The two-mile reach above the inflatable dam was surveyed to determine whether the impoundment altered the habitat type (SCWA 2000b). This reach is generally run-habitat when the dam is not inflated and primarily pool habitat when the dam is inflated. Aerial photographs and brief field reconnaissance in the area in late 1999 indicate a single-channel river that has a relatively straight trajectory with long sweeping oxbow characteristics through the area. It appears to have relatively few structural features that would create low areas outside of the main channel. The slopes of the river margins are relatively low gradient, but are sloped to the main channel. Bank stability has not been affected by gravel bar grading activities.

When gravel bars are graded, streambed sediments are disturbed. During the first flush of the rainy season, loose sediments may be mobilized and increase turbidity levels. These are likely to be short-term effects. Because these gravel bars are located in the lower river, these sediments are not likely to be deposited in primary spawning or rearing habitat. Therefore, effects to habitat are likely to be low.

In summary, the risk to migrating juvenile salmonids from gravel bar scraping activities related to potential injury to fish (type of operation and magnitude of activity) is none at the Wohler, Bridge, and McMurray bars (upstream of the inflatable dam) and low risk at the Mirabel area operation. Since work at the upstream gravel bars is done outside of the wetted channel, it is not expected that fish would be trapped, or that there would be additional sediment input to the river. The potential to injure juvenile steelhead at Mirabel is greater than at the upstream bars because there is a possibility steelhead may be trapped in the Mirabel Bar. Fish rescues reduce the risk. Gravel bar grading at the Mirabel Bar normally occurs later in the summer, and during fish rescues in the 1999 portion of the monitoring study, no salmonids were found.

The potential risk to juvenile salmonids is greatly reduced for the Mirabel area because the timing of the operation does not normally coincide with migration of the salmonids. The potential to alter habitat with sediment input from instream activities is addressed through implementation of BMPs. The use of BMPs during gravel bar scraping activities reduces the potential for juvenile fish stranding. Spawning does not occur in this area. Effects from gravel bar grading operations are restricted to immediate, short-term effects, including a low risk of entrapment of migrating juveniles and short-term turbidity spikes. Therefore, the overall risk for injury and habitat degradation is low. If additional bars form in the future that may need grading, particularly between Caisson 6 and Caisson 3, the same BMPs would be applied to minimize the risk to salmonids and their habitat.

5.4.6 NPDES Permit Activities

The City of Santa Rosa, County of Sonoma, and SCWA (co-permittees) are co-permittees under an NPDES permit for stormwater discharges from separate municipal storm sewers.

During the years that the first permit was in effect, the co-permittees have determined that the plans and associated activities have been effective. Chemical and biological monitoring results since 1998 indicate that there have been no consistent trends or specific water quality constituents of concern identified (City of Santa Rosa, Sonoma County Water Agency, County of Sonoma 1998, 1999, 2000, and Sonoma, County of, City of Santa Rosa, and Sonoma County Water Agency 20032003). Bioassay results indicate very low toxicity of stormwater from sampled runoff events. Indirect indicators, including number of inspection and enforcement actions, amount of educational materials distributed, and amounts of pollutants removed through maintenance, spill response, and implementation of BMPs, indicate that the SWMP has been successful to-date. NPDES plan activities likely have a beneficial effect on listed species and their habitat.

5.5 Restoration and Conservation Actions

Proposed restoration and conservation actions in the Russian River watershed will have a range of effects on listed species and their habitats. This section provides:

- An overview of the level of SCWA's restoration and conservation actions within a given year and a description of how priorities are set.

- An overview of the Russian River watershed to put specific restoration actions into context.
- A qualitative assessment, based on evaluation criteria, of the biological benefit of proposed projects for affected life-history stages of listed salmonids.
- An assessment of effects due to construction and maintenance practices of the projects.

Some actions have been implemented since the MOU was signed (December 31, 1997), and represent an improvement to baseline conditions. They do not require a take authorization because they are not likely to result in direct injury to listed fish species. Actions that require take authorization are generally projects that require instream work while listed fish species may be present.

5.5.1 Program Overview

5.5.1.1 Funding and Priorities

SCWA commits substantial funds, staff, and equipment to restoration projects. The value of this commitment is maximized by prioritizing projects on a basinwide level, through cooperation with many other stakeholders, and by seizing opportunities for public education and outreach. Moreover, SCWA's success with grant writing has been, and would continue to be, used to supplement this effort.

SCWA has increased its budget and level of efforts for restoration and conservation actions within the last several years, and hopes to maintain the current budget in future years. Of the $800,000 spent on the Natural Resources program in 2000, about 30 to 40 percent was spent on monitoring at the Mirabel and Wohler diversion facilities (which has yielded valuable information about how listed species use the watershed), about 50 percent was spent on Fisheries Enhancement Program (FEP) projects, and about 10 percent on meetings. Additionally, in-kind contributions of SCWA staff and equipment have been committed to stream restoration projects. For example, $31,000 was committed for a large project on Copeland Creek and $7,000 for a project on Austin Creek.

In 1999, SCWA began to apply for grant money to supplement the restoration budget. For example, SCWA secured $400,000 of Proposition 13 funds to fund a program implemented by Circuit Rider Productions, Inc. for *Arundo donax* (Giant Reed) eradication in the Russian River watershed. The grant application was successful because a comprehensive approach to *Arundo* eradication was designed, rather than relying on less-effective spot treatments. This program includes mapping the entire watershed, developing a disposal and compost facility, and conducting eradication from the most upstream location to downstream areas. The mapping stage has been completed, and *Arundo* removal has begun. In some cases, SCWA has used grant money to jump-start projects by local organizations that match grants. In 2000, SCWA secured $471,000 in grants. If a landowner wanted to implement a joint project, SCWA would pursue a grant for that project. Given past successes, SCWA expects to secure additional grant funding in the future.

To maximize the effectiveness of the dollars invested, SCWA develops project priorities on a basinwide level. Stream habitat inventories coordinated by CDFG have identified restoration opportunities, and SCWA and CDFG have had a successful track record in working on multiple projects and efforts throughout the watershed. SCWA would work to implement the priorities and recommendations outlined by CDFG in its *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002). The contribution of funding and implementation efforts from other stakeholders in the watershed—private landowners, agencies such as CDFG, NOAA Fisheries, the Sotoyome Resource Conservation District, and NCRWQCB, to name a few—have been instrumental to the success of restoration programs.

SCWA bases its decision to proceed on a project on one or more of the following considerations.

- Project has a known benefit. Projects that meet significant known needs and result in maximum benefit are given priority. A project may have been identified as a priority during a habitat survey and in consultation with CDFG. Relevant information is reviewed, including formal or anecdotal information from SCWA or CDFG staff or others, including whether a limiting factor is affected, and potential effects to the population of a listed species (with a priority focus on coho salmon). For example, some streams might have adequate spawning habitat, but need large woody debris to provide adequate rearing habitat. If a project has a small footprint but affects a large area (for example, 700 feet of work that provides fish passage past Mumford Dam affects 45 miles of stream), more value from the project can be realized. If a project has educational value as a demonstration project, it is considered more valuable.

- Opportunity-based project (willing landowner). Occasionally, a project is requested by a local landowner and approved by CDFG. Because so much of the watershed is in private ownership, landowner cooperation is important. Publicity about SCWA programs and demonstration projects that have already been implemented may increase the number of such opportunities in the future.

- Third-party cooperation. As information about SCWA programs spreads, individuals or organizations seek opportunities to develop cooperative projects.

- Another organization is better equipped. If SCWA sees a restoration opportunity that may be handled more effectively by another organization, it would contact that organization. For example, SCWA is well equipped for dam removal projects, but there may be a large fencing project that may be more appropriately handled by the California Conservation Corps (CCC) office in Ukiah.

SCWA is also providing staff and substantial support for federal and state salmonid recovery planning efforts. As of the end of 2003, SCWA has allocated $4.6 million for recovery planning.

5.5.1.2 Evaluation Criteria Scoring

Conservation and restoration actions discussed in Section 5.5 were evaluated quantitatively by assessing their biological benefits. Typically, larger projects provide more biological benefits than smaller projects. The biological benefit score was based on the project size (length of stream affected), the time frame for expected benefits, habitat elements affected and their relative importance to listed fish species, stream inventory and/or population data, the cost vs. benefits of the project, and the educational value of the project.

Some projects have effects beyond the immediate project area. For example, a series of small instream structures can beneficially change the habitat unit ratios of an entire reach (pool/run/riffle ratio). The habitat value was qualitatively assessed by considering the duration and time frame to development, effects to canopy cover, instream cover, sediment, and bank erosion. The importance of the project for improving a limiting factor was considered. Ranking was based on a range of 1 to 5 with a score of 5 given to projects with the most substantial biological benefits.

5.5.2 Salmonid Habitat in the Russian River Basin Relative to SCWA Restoration and Conservation Actions

An analysis of the effects of restoration and conservation actions on coho salmon, steelhead, and Chinook salmon requires an understanding of the importance of various geographic areas to the species' various life-history stages. Activities within a particular geographic area can then be assessed for their overall effect on populations of listed species.

SCWA has cooperated with CDFG to conduct stream habitat surveys. Surveys for all of the coho salmon streams and most of the watershed have been completed. The CDFG *Draft Russian River Basin Fisheries Restoration Plan* (CDFG 2002) lists priorities for restoration based on stream inventory data. Streams that can support coho salmon are given first priority.

Much of the watershed area is privately owned, and agricultural industries (such as vineyards) predominate. Restoration actions can be limited by a lack of willing landowners, so public outreach and demonstration projects are an important component of a restoration program.

Santa Rosa and the Cotati-Rohnert Park areas are the most urbanized portions of the watershed. These areas contain most of the constructed flood control channels. Natural streams and constructed channels in the Rohnert Park area are generally low-gradient and run through a valley plain to the foothills. Poor summer water quality and low summer flows limit rearing habitat. However, the Laguna de Santa Rosa has important wetland and flood control functions for this part of the watershed.

Santa Rosa Creek drains to the Laguna de Santa Rosa, which in turn drains to Mark West Creek. This part of the Mark West Creek watershed, including the Santa Rosa Creek watershed, contains good coho salmon and steelhead rearing and spawning habitat. Much attention has been given in recent years to restoration opportunities in this area.

The western side of the Russian River valley is cooler, and primary coho salmon spawning and rearing habitat occurs in tributaries in this region. Good quality coho salmon habitat also occurs in the Upper Russian River watershed and in parts of the Mark West and Maacama Creek watersheds.

5.5.3 Instream Habitat Improvements

By providing improved and/or additional rearing habitat, instream habitat improvements are important to the survival of coho salmon and steelhead in the Russian River watershed. When riparian cover is planted along streambanks, water temperature is reduced, additional cover is provided, streambanks are stabilized, erosion is reduced, and additional plant material becomes available to provide food and cover for insects upon which juvenile fish feed. Fish passage is also improved.

Instream habitat structures consisting of large woody debris, such as rootwads, have been installed to give fish protective cover from predators and to create pools. Bank stabilization and riparian planting have been implemented. Trees have been planted where riparian cover was lacking. Other types of structures such as boulder or log weirs, or some other combination of structures (as outlined in CDFG's *California Salmonid Stream Habitat Restoration Manual* [Flosi et al. 1998]) may be implemented. Channels may be reconstructed. For example, a section of Big Austin Creek was reconstructed to convert a braided, intermittent channel to a single thread, perennial stream, with a reconstructed spawning area. Other activities could include placement of spawning gravels, removal of obstructions, culvert improvements, or slide removal.

An individual project may be small in scale, but may make beneficial changes to a larger habitat unit, or to the proportion of habitat unit types in a reach (pool/run/riffle ratio). For example, Mill Creek has 14 sets of instream habitat structures. While each structure is short, collectively they change a long section of stream from primarily riffle habitat to a better combination of pool/riffle habitat.

SCWA has funded or implemented instream habitat improvements in Green Valley, Mill, Felta, Dutch Bill, Palmer, and Dry creeks. These projects greatly improve the habitat value of significant stretches of these streams for rearing salmonids. Table 5-59 summarizes information about these projects and shows a biological benefit score.

CDFG has recommended that these creeks be managed as anadromous, natural production streams. Moreover, SWCA has targeted these creeks for their importance to coho salmon and steelhead recovery. Where coho salmon or steelhead are known to be present in a particular stream, it is noted. However, improvements to habitat are likely to increase fish abundance in streams, and it may be possible for coho salmon to begin to use a stream in which they have not recently been documented, especially if there is a change in the pool/riffle/run ratio.

Table 5-59 Instream Habitat Improvement Projects

Creek	Size of Projects	Type of Project	Species* Affected	Biological Benefit	Project Completion Year
Green Valley	~ 1 mile	4 instream habitat structures	Co, St	5	2000
Mill	~ 2 miles	14 sets of instream habitat structures	St	5	1998
Felta	~ 2 miles	14 sets of instream habitat structures	Co, St	5	1998
Dutch Bill	6 pools	7 habitat structures	Co, St	5	2000
Projects that Require Take					
Dry	14 miles	Instream habitat structures	Co, St, Ch	5	
Palmer		Instream habitat structures	St	5	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

In spring 1995, CDFG surveys in Mill Creek documented many Age 0+ steelhead, indicating successful spawning, but few yearling fish, indicating poor holding conditions. The instream habitat project in Mill Creek will provide additional rearing habitat. The Green Valley, Felta, and Dutch Bill creek projects are particularly important because coho salmon have been documented in recent years. Dutch Bill Creek is a major tributary to the Lower Russian River and is therefore easily accessible to spawning salmonids. Palmer Creek is important because it contains good quality salmonid habitat.

5.5.3.1 Proposed Dry Creek Restoration

SCWA is planning restoration work for Dry Creek that would include constructing habitat improvement structures at suitable locations using boulders and redwood or fir trees to increase habitat complexity and available cover, and to provide areas that would hold coho spawning gravels. Coho salmon spawning gravels are smaller than those used by steelhead or Chinook salmon (Kondolf and Wolman 1993) and are therefore at a greater risk of being scoured during high flows.

Salmonids are most likely to construct redds in areas where periodic scour and fill of streambed gravels provide clean gravels that resist transport under all but the highest flows. Coho salmon redds are more vulnerable to redd-scouring stormflows, as they typically spawn early in the winter season, and in areas with smaller, more easily eroded gravel. Subsequent storms may be numerous, and peak flow events often occur after coho salmon have completed redd construction and egg laying.

Structures such as logs, large woody debris, or boulder clusters placed within the Dry Creek stream channel would create combinations of shear zones and pockets of slower moving water velocities surrounding the structures, and would serve to trap sediments during high-flow events. Deposits of clean, well-sorted gravels are likely to form near these structures, creating high-quality spawning sites. Protected gravels are also less likely to scour than gravels at some distance from the structures.

Dry Creek provides little available habitat for coho salmon (ENTRIX, Inc. 2003b) due to poor channel structure (i.e., general lack of pools or edge habitat with complex cover), and the general lack of woody debris. These features constrain production of both fry and juvenile coho salmon. Substantially increasing the amount and quality of habitat for coho salmon juveniles by adding structures would allow this stream to support larger numbers of fry and juveniles, and most importantly would lead to higher production of smolts. Placement of large woody debris within the channel would also improve rearing habitat for anadromous salmon and steelhead. This would provide refuge from high water velocities, supply cover for escaping avian predators, and encourage deposition of loose gravels and cobbles favored by invertebrate prey.

Dry Creek's habitat for young steelhead and Chinook salmon is affected in part by low habitat complexity. Habitat structures placed adjacent to high-velocity areas would benefit steelhead juveniles by providing velocity refugia adjacent to feeding lanes with abundant prey. All young salmonids would benefit from increased protection from high velocities associated with flows greater than 130 cfs (ENTRIX, Inc. 2003b).

Implementation of this project on Dry Creek would rate an effect score of 5. This project would greatly improve overall physical and, particularly, spawning habitat (coho salmon) in this stream.

Instream habitat improvement projects are likely to result in short-term increases in turbidity during construction if the work is done in a wetted stream, and during the first high-flow event of the following rainy season. Work in a wetted stream also has the potential to injure fish that may be in the area during construction. These potential effects are assessed in Section 5.5.8. Construction of instream habitat improvement projects may require take authorization.

5.5.4 RIPARIAN RESTORATION

Riparian restoration projects include projects that exclude livestock from riparian zones, replant degraded areas with native vegetation, provide temporary water supplies to increase survival of newly planted trees, place bioengineered erosion structures such as willow mattresses and baffles, and/or plant native riparian trees in upslope areas.

Several general effects can be realized from riparian restoration. While reestablishing native riparian vegetation, this action, in turn, replenishes the natural functions of the riverine ecosystem. When riparian cover planted along streambanks has matured, water temperature is reduced, additional cover is provided, streambanks are stabilized, erosion is reduced, and additional plant material becomes available to provide food and cover for insects upon which juvenile fish feed. This is particularly beneficial for juvenile coho salmon, steelhead, and Chinook salmon rearing, but there may also be water-quality benefits for adult spawners. Furthermore, riparian cover can moderate temperatures for egg incubation. Passage conditions for juvenile fish may also be improved.

5.5.4.1 Fine Sediment Reduction

Riparian vegetation stabilizes or intercepts fine sediments that can smother eggs in the project area or in areas downstream. Sediment input into the stream reduces the amount of habitat for invertebrates and instream cover available to rearing juvenile fish by filling interstitial spaces under and between rocks. Projects that reduce sediment input to the stream often affect long portions of the channel downstream. Even projects of small size can have beneficial water-quality effects that extend downstream.

5.5.4.2 Livestock Exclusion

By fencing livestock from the riparian zone adjacent to the stream and replanting degraded areas with native vegetation, streambanks have become stabilized, riparian vegetation has been reestablished, and animal waste entering the stream has decreased. Benefits are realized within the project area and in downstream reaches.

5.5.4.3 Overall Benefits

Riparian restoration activities have the potential to affect all life-history stages of salmonids. As riparian vegetation takes some time to mature, the benefits of riparian restoration may take several years to be fully realized. Because riparian restoration activities often involve regrading streambanks, there may be some immediate reduction in sediment input to the stream and bank degradation.

Table 5-60 summarizes information about a number of riparian restoration projects on selected streams and shows a biological benefit score for each. Where coho salmon or steelhead are known to be present in a particular stream, it is noted. Improvements to habitat will likely increase future use by listed species. These creek projects are discussed in more detail following.

Table 5-60 Riparian Restoration Projects

Creek	Size of Project(s)	Type of Project	Species* Affected	Biological Benefit Score	Project Completion Year
Copeland	6,000 ft.	Fencing, grading, riparian planting;	St	4	1999, 2000, 2003
		Propagation of native plants and control of invasive non-native plants.	St	4	Funded since 2001

Table 5-60 Riparian Restoration Projects (Continued)

Creek	Size of Project(s)	Type of Project	Species* Affected	Biological Benefit Score	Project Completion Year
Green Valley	30 ft.	Erosion control and riparian planting	Co, St	Co - 5 St - 3	
Howell	4,000 ft.	Fencing	St	4	2000
Lytton	15 acres riparian habitat	Riparian planting with environmental education	St	5	2001
Turtle	500 ft.	Willow walls & mattresses	Co, St	3	1999
Turtle	> 1 mile	Irrigation	Co, St	5	1999
Felta	3 projects	Willow walls	St	3 (x3)	1999
Russell Irrigation Site on Turtle Creek	> 1 mile	Fencing	Co, St	4	1999
Unnamed tributary to Mark West (Huff property)		Willow wall	Co, St	3	1998

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.4.4 Copeland Creek

The project is on a valley floor reach of the stream in the Rohnert Park area. The watersheds within this area contribute substantial sediment loads to downstream areas. This portion of Copeland Creek goes dry in early summer, as does a downstream reach along Sonoma State University.

Approximately 6,000 feet of Copeland Creek streambank was restored when cattle and horses were excluded, eroded streambanks were recontoured, and native riparian species were planted. The project was implemented over 4 years. Sediment input to the stream was reduced when project components were completed, but it may take a few years for effects to be substantial in the stream and in downstream areas. Once the riparian vegetation has matured, additional and improved rearing habitat will be available.

Although the project will no doubt have ecological value for other biological resources, there is probably limited value for steelhead rearing in the immediate area. However, this is a project of significant size, and a reduced sediment load to the stream will benefit downstream portions of the watershed. The creek empties to the Laguna de Santa Rosa, which has important wetland and flood control functions. Portions of the Laguna de Santa Rosa, particularly areas where tributaries flow into it, may provide important salmonid habitat. The USACE is conducting a feasibility study to investigate the extent and causes of sedimentation in the Laguna de Santa Rosa. The Copeland Creek project will likely help reduce the sediment load to the Laguna de Santa Rosa. Such a large increase in the riparian zone is also likely to reduce water temperatures. Therefore, the biological benefit score is 4.

Since 2001, SCWA has funded Sonoma State University to offer a course in native plant propagation. Utilizing expertise and facilities on the campus, the course supplies the Copeland Creek watershed and other watersheds in the area with native plant materials, plant storage, and propagation services. In addition to direct benefits to salmonid-bearing streams from these restoration activities, this program educates students in the practical aspects of plant propagation and related restoration techniques.

SCWA has also funded efforts at Sonoma State University to study and control two invasive tree species that were threatening the native plant community on Copeland Creek: Tree of heaven (*Ailanthus altissima*) and sweet cherry (*Prunus avium*). These projects eliminated the dominant exotic canopy species from a large section of Copeland Creek and replaced them with native vegetation. These species can quickly become the dominant plant species and exclude native species. *P. avium* and *A. altissima* are small, relatively short-lived tree species that produce lower quality riparian and instream cover than the native trees they displace (e.g., oaks, maples, ash). In addition to restoring a high-quality riparian corridor, these projects increase our understanding of the dynamics of the spread of invasive species and the threat they pose to local streams. Although the project directly affects a localized area, the information gained from studies like these can be applied elsewhere in the watershed. Therefore, the biological benefit score is 4.

5.5.4.5 Green Valley Creek

Green Valley Creek is one of the few tributaries in the watershed that has supported a self-sustaining population of naturally-spawning coho salmon. Restoration actions on this creek may be particularly useful for conserving a native strain of coho salmon. Numerous small-scale projects have been implemented. Although the immediate project area of each one is generally small in size, the biological benefit for coho salmon may be high.

5.5.4.6 Lytton Creek

Restoration of 15 acres of native riparian habitat improved the riparian corridor of this salmonid-bearing stream. Because this project involved local high school students and members of the local community, it had a substantial educational value. It demonstrates that healthy ecosystems and farming can coexist. Therefore, the biological benefit score is 5.

5.5.4.7 Howell Creek

A 1998 CDFG stream inventory indicated that both riparian vegetation and stream channel conditions were degraded by unrestricted cattle grazing in an approximately 4,000-foot-long reach of Howell Creek, a tributary in Mendocino County. Marginal habitat for steelhead existed there. Exclusion of cattle and planting of native riparian species improved the streambanks and bed of this reach. Development of off-stream water sources helped to eliminate the need for cattle access. Reduction of fine sediment input, reestablishment of the riparian corridor, and reduction of streambed disturbance increase the habitat value of this and downstream reaches for rearing steelhead. Because this is a relatively large project with beneficial effects that extend downstream, the biological benefit score is 4.

5.5.4.8 Turtle Creek

The landowner for the Russell Irrigation site on Turtle Creek participated in a voluntary fencing project to exclude cattle from the stream in 1997. Because the creek was the main source of drinking water for Russell's livestock, an alternative water source was subsequently constructed. Water quality has been improved and riparian vegetation has a chance to mature. Fish habitat can be dramatically improved by this kind of conservation action. Over a mile of stream was fenced, and reduced sediment input will affect downstream reaches as well; therefore, the biological benefit score is 5.

5.5.5 Instream and Riparian Habitat Restoration

Instream structures promote pool and riffle habitats and provide bank stability. Large projects in Austin, Brush, Big Austin, Palmer, and Santa Rosa creeks include both instream and riparian habitat improvements. Green Valley and McNab creeks also have projects that includes erosion control, revegetation, and instream habitat structures. Because Green Valley Creek is one of the few creeks in the watershed that appears to still have a naturally-spawning coho salmon population, restoration projects are especially valuable. Biological benefit scores for these actions are summarized in Table 5-61.

Table 5-61 Instream and Riparian Restoration Projects

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Austin	2,500 ft.	5 boulder wing deflectors, 7 log/root wad structures, 3 willow baffles, native plants	St	5	
Brush	1,200 ft.	Streambed and bank regrading, instream structures, revegetation	St	5	1999
Big Austin	1,300 ft.	Reconstructed channel	Co, St	5	1998, 2000
Big Austin	0.5 mile	13 erosion control/riparian structures, willow baffles, willow wall, slide repair	Co, St	5	1998, 2000
Green Valley		Erosion control, revegetation, 2 instream habitat structures	Co, St	Co - 5 St - 4	2001
McNab		5 streambank stabilization sites and 9 instream structure sites	St	5	2001

Table 5-61 Instream and Riparian Restoration Projects (Continued)

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Palmer	3,000 ft.	7 instream habitat structures, 1,000 alder trees	Co, St	5	1998
Santa Rosa Creek	12.8 miles	Restore channelized creek to more natural form and function	St	5	2002

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.5.1 Brush Creek

Brush Creek channel was previously modified to handle a 100-year-flood event to protect local property. Spawning habitat has been available, but high summer temperatures have limited rearing habitat. Work was needed to restore salmonid habitat and to lower stream temperatures. Brush Creek restoration between the confluence with Santa Rosa Creek and Highway 12 was completed in 1999. Grading streambed and banks along 1,200 lf of the stream and implementation of instream structures have enhanced aquatic and riparian habitat throughout the project area. Improving pool and riffle habitats as well as bank stability has provided spawning and rearing habitat for steelhead. Native vegetation was also planted along the regraded banks. As this vegetation matures, it will provide cover, lower stream temperatures, contribute to the food chain, and reduce runoff and bank erosion, which will, in turn, improve conditions in Santa Rosa Creek. Given the amount of habitat that was improved in an area important to steelhead rearing, the biological benefit score is 5. The Brush Creek project also occurs in a heavily populated area of the watershed and therefore is useful for public education.

5.5.5.2 Big Austin Creek

Fish habitat was improved when 1,300 feet of braided, intermittent channel was reconstructed to single-thread perennial stream. The project included bank stabilization, placement of instream cover, and construction of willow baffles. Riparian vegetation was also planted along sections of the stream. As riparian vegetation matures, it will increase cover and reduce water temperature. Site monitoring in 2002 to 2003 showed that the site is stable. This project provides substantially improved coho salmon and steelhead spawning and rearing habitat.

5.5.5.3 Palmer Creek

Palmer Creek is a tributary to Mill Creek in the Dry Creek watershed. This project was implemented in summer and fall 1998. Instream structures, including seven cover/scour structures (logs and boulders), enhance 3,000 feet of coho and steelhead habitat. The 1,000 native alder trees that were planted will improve the riparian corridor. The size of the project, as well as its location in the watershed, make it important for coho salmon and steelhead spawning and rearing habitat.

5.5.5.4 Santa Rosa Creek

The City of Santa Rosa is undertaking a project to restore Santa Rosa Creek by returning substantial reaches of degraded, channelized creek to a more natural geomorphic and ecological form and function and improving water quality, while maintaining existing levels of flood protection. The USACE, SCWA, and Sonoma County are assisting the City of Santa Rosa. The restoration is also intended to benefit steelhead and other aquatic life. This is a very large project (12.8 miles) that is likely to result in much-improved water quality and restored habitat for listed fish species. Santa Rosa Creek (including some of the downtown reaches) has been identified as having value as spawning and rearing habitat (CDFG 2001b).

5.5.5.5 McNab Creek

McNab Creek is a potential salmonid-bearing stream in the Ukiah area (CDFG 1998b). SCWA funded the E Center's Mendocino Fisheries Program project that stabilized stream banks at five sites with bioengineering techniques and installed instream structures at nine sites. The instream structures created pools and improved rearing habitat. This project improved salmonid-rearing habitat in the vicinity of each of these sites, as well as reduced sediment input to downstream reaches. Therefore, the project benefit score is 5.

5.5.6 Rural Road Erosion Control

Projects that control rural road erosion reduce sediment runoff into valuable spawning and rearing habitat, and often help to reestablish riparian vegetation. Fine sediment can "smother" eggs by decreasing the amount of intergravel DO available to them. The habitat of aquatic insects that juvenile fish feed on can be buried. Primary productivity is reduced in turbid water. As salmonids are "sight feeders," their ability to feed in turbid water can be reduced. Increased sedimentation can bury the interstitial spaces in the substrate used by invertebrates and instream structure available for juvenile fish to use as cover. Some erosion-control activities, such as regrading banks or soil treatments, have immediate reductions in soil loss, but it may take several years before improvements are noted in the stream. Moreover, these activities often require the growth and establishment of riparian vegetation, so the time frame to full development may be 2 to 4 years. However, once they are established, these kinds of conservation actions can have dramatic and long-term effects. Furthermore, immediate and long-term project effects can occur in long distances downstream of the project site.

Two road erosion control projects are detailed below and given evaluation scores in Table 5-62. One is a project to decrease the sediment runoff from a road adjacent to Palmer Creek. The other reduces sediment runoff to Santa Rosa Creek in Hood Mountain Regional Park.

Table 5-62 Road Erosion Control Projects

Creek	Size of Project	Type of Project	Species Affected*	Biological Benefit Score	Project Completion Year
Palmer	1 mile	Road erosion control, instream structures	Co, St	5	2001 (additional work in 2000, 2001)
Santa Rosa (Hood Mtn.)	~100 yards	Road and landslide erosion control	Co, St	5	2000

*Co = coho salmon, St = steelhead

5.5.6.1 Palmer Creek Road Erosion Control

This project reduced sediment input from one mile of steep rural roadway within the Palmer Creek watershed. Reducing sediment input into the stream has enhanced the value of instream habitat structures funded by SCWA within this stretch of Palmer Creek.

A long portion of Palmer Creek is affected, but there has not been an acute sediment input problem to the stream. While sediment input to the stream was reduced when the project was completed, it may be several years before significant improvement of habitat quality in the stream may become apparent. This project improves rearing habitat for juvenile coho salmon and steelhead by decreasing siltation of cover, reducing turbidity, and improving habitat for aquatic insects. Furthermore, habitat for egg incubation for all three species that may exist at this site or downstream of it will be improved. The biological benefit score is 5.

5.5.6.2 Hood Mountain Regional Park

An eroding road adjacent to Santa Rosa Creek and a landslide on Hood Mountain Trail deliver fine sediment to the creek. The slide was stabilized, the road modified, and the slope gullies filled. This project significantly reduced erosion along about 100 yards of streambank, and reduced sediment input to downstream areas. Although sediment input to the stream was reduced, it may be several years before significant changes are seen in the streambed itself. Because this landslide has been a significant source of fine sediment input to the stream, the biological benefit score is 5. As the section of Santa Rosa Creek in the park contains valuable spawning and rearing habitat for steelhead and coho salmon, the project is particularly important.

5.5.7 Fish Passage

The primary benefit of fish passage is that additional spawning and rearing habitat becomes available to anadromous salmonids. The biological benefit from a fish passage project is proportional to the quality and amount of upstream habitat made available. Scores for specific projects are given in Table 5-63. All of the listed projects are given a score of 5 because a large quantity of habitat is made accessible. The Santa Rosa and Mumford Dam projects are especially beneficial because they provide access to high-quality habitat, provide it for coho salmon as well as steelhead, and in the case of

Mumford Dam, for Chinook salmon. These projects restore habitat connectivity, which benefits the ecological community that includes salmonids.

In general, fishways could increase predation on listed species if they concentrate juvenile salmonids. Because these fish passage projects do not concentrate juvenile salmonids, they do not increase the risk for predation on juvenile salmonids and do not increase the risk of poaching.

Table 5-63 Fish Passage Projects

Creek	Upstream Habitat Affected	Type of Project	Species Affected*	Biological Benefit Score	Year Completed
Santa Rosa (Hood Mtn)	10 miles	Rock weirs	Co, St	5	1999
Mumford Dam	45 miles	Rock weirs ~ 600 feet of channel	Co, St, Ch	5	2002
Crocker Dam	4.5 miles	Series of weirs. Regrade, stabilize and replant streambanks	St	5	2002

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.7.1 Mumford Dam Modification

Mumford Dam is an 8-foot-high dam, approximately 60 feet wide, located on the Russian River near the town of Redwood Valley. Since its construction in the early 1900s, the streambed downstream of the dam was down cut between 8 to 15 feet, which virtually eliminated fish passage and caused massive erosion and bank failure for approximately 600 feet downstream of the dam. Restoration involved recontouring the streambanks to a more stabile profile, revegetating with native plants, and constructing a series of weirs to facilitate fish passage. The dam owner also upgraded the diversion to comply with NOAA Fisheries screening criteria. A series of large rock weirs maintains the thalweg of the river, stabilizes the channel bed, and reduces bank erosion.

This project greatly improves upstream fish passage, making approximately 45 miles of high-quality spawning and rearing habitat available for steelhead and Chinook salmon, and possibly coho salmon, on the Russian River upstream of the Forks. As the native riparian vegetation becomes established, the streambank will be stabilized even further, and habitat within the 600-foot-long project area will be greatly improved. The reduction in bank erosion will also improve water quality in downstream reaches. Because a large amount of habitat is improved and made available for all three listed species, the biological benefit score is 5.

5.5.7.2 Crocker Creek Dam

When Crocker Creek Dam failed, the impact to Crocker Creek was significant. A large sediment load was released downstream from behind the dam, and the creek upstream of the dam experienced major erosion and collapsing banks. The remaining structure and associated debris pile formed a potential barrier to salmonid migration.

Components of the restoration project included demolishing and removing the remaining structure and debris, recontouring and revegetating the banks, and making biotechnical channel adjustments. The left and right banks upstream of the dam for a distance of 250 to 400 feet were regraded, reconstructed, and replanted with willows. An irrigation system was installed to water the vegetation until it is well-established. This project restored access for anadromous fish to 4.5 miles of creek, stabilized and revegetated streambanks in the vicinity of the dam, and reduced sediment input to downstream habitat. Because there are benefits for both upstream and downstream habitat, the biological benefit score is 5.

5.5.7.3 Santa Rosa Creek

Like the Mumford Dam modification, a series of large rock weirs at a rural road stream crossing in Santa Rosa Creek in the Hood Mountain region is designed to stabilize the channel bed and improve upstream fish passage. The project lowered the concrete road crossing and sloped the downstream side of the sill to reduce the jump height for fish. Rock baffles were installed on the downstream side of the sill to improve fish passage. The project was implemented by Dragonfly Stream Enhancement with a $7,685 FEP grant from SCWA. This project makes approximately 45 miles of quality spawning and rearing habitat available upstream. Therefore, the biological benefit score is 5.

5.5.8 CONSTRUCTION, MAINTENANCE, AND OPERATION ACTIVITIES ON RESTORATION PROJECTS

Construction activities are likely to have minimal, if any, short-term effects on listed species or their habitat. These effects include short-term increases in turbidity and sediment input or a slight risk of injury to some individual fish. Therefore, instream and rural road erosion projects that are implemented in a wetted stream require a take authorization. As restoration projects act passively after construction is complete, no maintenance or operations effects are anticipated.

5.5.8.1 Riparian Restoration Projects

When riparian restoration projects are constructed on streambanks, instream work is not necessary. There is no potential for direct injury to fish during construction activities, and therefore, riparian restoration activities do not require take authorization. Installation of fences and establishment of native riparian vegetation could create limited-to-high levels of streambank disturbance, which, in turn, could increase sediment input to the stream. Bank erosion control measures such as detention basins, hay bales, and filter fabrics would be used as necessary. Upslope stability is improved once vegetation is established. The sediment containment score for riparian restoration projects is 3 (Table 5-64).

Table 5-64 Sediment Containment Scores for Riparian Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
5	No upslope disturbance, or an increase in upslope stability.	
4	Limited disturbance with effective erosion control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	Revegetation and erosion control projects
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

5.5.8.2 Instream and Rural Road Erosion Projects

Many instream habitat and road erosion projects are constructed when the stream is dry. For those streams, there is no sediment input to the stream and no potential for direct injury to fish during construction activities (Table 5-65). For the few channels that are wetted during construction, fish rescue would be performed. Turbidity and sediment input may increase during the first high-flow event of the rainy season. But these effects would be of short duration and may be indiscernible from turbidity normally associated with these events.

Table 5-65 Opportunity for Injury Scores for Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape or rescue provided, project area isolated from flow (if appropriate).	Instream habitat improvement and rural road erosion projects
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

When work is done in a wet stream channel, it is under the terms and conditions of the USACE, NCRWQCB, and CDFG permits issued for the project. All measures possible would be used to reduce effects on the stream. If it is not possible to work in a dry channel, the site would be dewatered and a fish rescue implemented, if appropriate. For example, on Austin Creek, reconstruction of the toe of the bank was necessary, and BMPs were stipulated in the permit. A combination of detention basins, hay bales, and filter fabrics were used, and no sediment problems were identified. On Adobe Creek (not in the Russian River), a series of boulders were placed in an active stream to provide fish passage. Fish rescues were conducted to move as many fish as possible out of the project area. These examples demonstrate a clear commitment by SCWA to avoid any effects to the aquatic resources and listed species during implementation of restoration projects.

Sediment containment measures would be implemented in all projects (Table 5-66). While rural road erosion projects would result in short-term effects, with limited-to-high levels of disturbance to streambanks, effective erosion control measures are in place during construction when work is done near wetted channels. These projects are likely to increase upslope stability in the long-term.

Table 5-66 Sediment Containment Scores for Restoration Projects

Category Score	Evaluation Criteria Category	Project Scores
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	Projects in dry channels
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	All projects in wetted channels
2	Limited sediment control.	
1	No instream sediment control.	
	Component 2: Upslope Sediment Control	
5	No upslope disturbance, or an increase in upslope stability.	Instream structures
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	Rural road erosion control projects
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

5.5.8.3 Fish Passage

Mumford Dam, Crocker Creek Dam, and Santa Rosa Creek fish passage construction projects were timed and implemented to minimize disturbance to rearing salmonids. While there was a risk to listed species and their habitat from construction activities, the use of standard BMPs made the risk low.

For any fish passage project, fish rescues would be performed, if necessary, reducing the opportunity for injury to fish (Table 5-67). Sediment traps or similar measures would be constructed to reduce instream sediment loads from construction activities. Bank erosion control measures would be used when planting native riparian vegetation, and up-slope stability would be improved once the vegetation is established (Table 5-68). Long-term benefits, including stabilized banks with a native riparian corridor and passage to additional spawning and rearing habitat, outweigh potential short-term risks to individual fish.

Construction activities are likely to have minimal, if any, short-term effects on listed species or their habitats. These effects include short-term increases in turbidity and sediment input or a slight risk of injury to some individual fish. Therefore, future construction of fish passage projects would require a take authorization.

Table 5-67 Opportunity for Injury Scores for Fish Passage Projects

Category Score	Evaluation Criteria Category	Project Scores
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or the tops of bars, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	
3	Appropriate BMPs are applied; e.g., project area survey, escape, or rescue provided, project area isolated from flow (if appropriate).	Mumford Dam, Santa Rosa Creek
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

Table 5-68 Sediment Containment Scores for Fish Passage Projects

Category Score	Evaluation Criteria Category	Project Scores
	Component 1: Instream Sediment Control	
5	Project area does not require rerouting streamflow.	
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	Mumford Dam, Santa Rosa Creek
2	Limited sediment control.	
1	No instream sediment control.	

Table 5-68 Sediment Containment Scores for Fish Passage Projects (Continued)

Category Score	Evaluation Criteria Category	Project Scores
	Component 2: Upslope Sediment Control	
5	No up-slope disturbance, or an increase in up-slope stability.	Mumford Dam, Santa Rosa Creek
4	Limited disturbance with effective erosion-control measures.	
3	Moderate- to high-level of disturbance with effective erosion control measures.	
2	Action likely to result in increased sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel or major changes in channel morphology.	

5.5.9 WATERSHED MANAGEMENT PROJECTS

Watershed management projects provide key information that is needed to restore and protect habitat for listed fish species, and make it possible to apply this information on a watershed level to maximize the effects. Evaluation criteria for scientific research, demonstration projects, and information dissemination such as: in how wide a geographic area could the information be used, and whether the information is useful for the protection of listed species or their habitats (Table 5-69).

Table 5-69 Information Value Evaluation Criteria

Category Score	Evaluation Criteria Category
5	Basinwide applicability.
4	A region or "type" of habitat (i.e., small tributaries or lower mainstem).
3	Isolated project/stream information.
2	Information not useful to listed species or habitat.
1	Incorrect or misleading information.

Research efforts, information dissemination, and regional coordination of management efforts are important components of the restoration and conservation of listed species and their habitat. Table 5-70 summarizes information about actions that are part of the proposed project, the biological benefit scores, and where known, indicates the listed species the action is likely to affect. Steelhead are the most abundant species in many of these areas, but as coho salmon populations are recovered, the use of these streams by these species is likely to increase. All projects listed are likely to improve habitat for spawning, rearing, and migration of listed salmonids.

Table 5-70 Information Value Scores

Project	Range of Applicability	Information Value Score
Data Collection		
Stream habitat surveys	Basinwide – SCWA focus on Mark West and Santa Rosa Creek watersheds.	**5**
Temperature	Major tributary watersheds, trends over multiple years.	**5**
Water quality sampling	Austin Creek and Maacama Creek tributaries, Russian River mainstem, Mark West, Santa Rosa, Green Valley, Mill, Ackerman, Robinson, Dutch Bill, Hulbert, Fife, Franz, Porter, Redwood creeks.	**4**
Coho salmon and steelhead population monitoring	Basinwide	**5**
Genetic studies on coho salmon, steelhead, and Chinook salmon	Basinwide	**5**
Arundo mapping and research	Basinwide	**5**
Laguna de Santa Rosa sedimentation study	Regional application – Lower Russian River floodplain.	**4**
Russian River coho recovery stream monitoring	Six stocking streams that are part of the Coho Salmon Recovery Program's comprehensive long-term monitoring, and 3 control streams	**5**
Green Valley Creek Spawning Substrate Study	Green Valley Creek	**5**
Russian River Habitat Mapping	35 miles of mainstem channel between the Forks and Cloverdale	**5**
Demonstration Projects		
Pierce's Disease control study	Maacama Creek site, with potential application to other vineyards.	**5**
Fish Friendly Farming	Vineyards, the dominant agricultural industry in the watershed.	**5**
Palmer Road erosion control	Demonstration project helpful for other work in areas with road erosion problems.	**3**
Information Coordination and Dissemination		
KRIS/GIS database	Basinwide	**5**
Restoration Project Database	Basinwide	**5**
Information dissemination: Workshops, newsletters, library, training programs, school projects	Several projects with regional applications.	**4**
Federal and state recovery planning assistance	ESUwide	**5**
NCRWQCB Russian River Basin Plan review	Basinwide, and application to entire ESUs of listed fish species.	**5**
Watershed Management Plan	Regional applications	**4**
North Bay Watershed Assn (NBWA) participation	Regional applications	**4**
Clean-up days	Target specific streams	**3**

Basinwide applicability (score 5) addresses most or the entire watershed that is likely to be important to listed species. Isolated project/stream information is likely to be useful in a localized area, such as a particular stream or stream reach. Isolated project/stream information (score 3) is likely to be useful in a localized area, such as a particular stream or reach of a stream. Scores are assigned for the various projects based on the range of applicability and on a qualitative assessment of the biological benefit that may accrue.

5.5.9.1 NCRWQCB Russian River Basin Plan Review

SCWA has provided funding for the NCRWQCB to review the Russian River Basin Plan to determine whether the Basin Plan's water quality requirements are sufficient to protect fish in the Russian River. This review may lead to changes in regulatory standards that increase protection of listed fish species. Changes in these standards would not only affect management of the Russian River watershed, but of the entire portion of the ESU of each listed fish species in the North Coast region, in coordination with other California state regional water quality control boards through the North Bay Watershed Association (NBWA).

5.5.9.2 Population and Habitat Surveys

SCWA is participating in a comprehensive survey of listed salmonid populations and their habitats throughout the Russian River. This information is key to effective management and restoration. Studies have also been funded to determine the genetic population structure in the Russian River and other watersheds in the ESU so that locally adapted "wild" stocks can be identified and given additional protection.

Population monitoring may result in injury or mortality to some individual fish. However, the benefits of having data to help effectively manage the resource outweigh the potential to harm some individual fish. Take of listed fish species is addressed in the NOAA Fisheries fish sampling permitting process.

5.5.9.3 Temperature Monitoring

The NCRWQCB, with funding from SCWA, has organized a Temperature Summit to coordinate various organizations to conduct comprehensive water temperature monitoring in the watershed. Priority is given to salmonid-bearing streams or impaired streams that need improvement. Collectively there are about 300 sample locations in the basin. Some organizations participating in the Temperature Summit have access to privately owned land that other organizations might lack.

Temperature data are entered into the KRIS database and are used in several ways. For streams that have good water temperatures but no salmonids, limiting factors for sensitive life-history stages are sought. Water temperature problems that might affect coho salmon are identified. This includes areas where water temperatures increase. Where possible, areas that contain subsurface flow for thermal refugia are also identified. CDFG monitors individual tributaries for one season. SCWA monitors temperatures over several seasons to document long-term trends. Combined, these data are crucial to help identify priority restoration opportunities.

5.5.9.4 Pierce's Disease Control

SCWA funded a study on Maacama Creek to investigate methods of controlling Pierce's disease. The study investigated means to selectively remove non-native plants that serve as sharpshooter hosts, while maintaining a viable riparian community. This project was conducted by researchers at the Division of Insect Biology, University of California, Berkeley. The study demonstrated that selective removal of vegetation can control an insect vector of Pierce's disease. Furthermore, the reductions in populations of glassy-winged sharpshooters have been greater than those achieved by insecticide treatments of riparian areas. The insects that carry Pierce's disease generally favor non-native vegetation. Leaving native vegetation that the insects do not use will help maintain the benefits of a healthy riparian corridor. If riparian vegetation is indiscriminately removed to prevent the spread of this disease, habitat for listed species can be degraded.

The information from this study could be applied in other riparian corridors that pass through vineyards. Because the need for information on effective control is actively being sought by growers, this information could significantly decrease the amount of riparian vegetation that is currently being removed from habitat.

5.5.9.5 Habitat Studies

The Russian River Coho Salmon Recovery Program's comprehensive long-term monitoring program will install stage and stream temperature monitoring equipment in six streams to be stocked with coho salmon, as well three control streams. These data are critical to the monitoring evaluation efforts for the reintroduction of coho salmon to restored habitat. Because this is an important component of the effort to increase the abundance of coho salmon in high-priority streams, the biological benefit score is 5.

SCWA has funded a joint effort between O'Connor Environmental, Inc. and Circuit Riders Productions to perform a fluvial geomorphic analysis and characterize spawning substrate in Green Valley Creek. Because this information will help guide restoration efforts on one of the only streams in the watershed that has had a naturally-spawning coho population in recent years, the biological benefit score is 5.

The Russian River between the Forks and Cloverdale contains some of the best Chinook salmon and steelhead spawning and rearing habitat in the mainstem. SCWA has funded a study to map the locations, depths, areas, and temperatures of pools, map and measure salmonid spawning sites, and map the locations of erosion sites. Because this study focuses on a long (35 miles) and important reach for these two species, particularly for Chinook salmon, the biological benefit score is 5.

5.5.9.6 Fish Friendly Farming

The Fish Friendly Farming program, implemented by the Sotoyome Resource Conservation District with SCWA's assistance, gives landowners the knowledge and incentive to practice beneficial management practices that protect fish habitat. Participants learn such topics as evaluation of natural features, current practices, roads, soils, slopes and drainage, and riparian corridor restoration and management. Because this program targets the region's dominant agricultural industry, wide-scale adoption of this program could result in fish habitat improvements in a substantial portion of the watershed.

When implemented, BMPs outlined in the *Fish Friendly Farming Certification Program Farm Conservation Plan Workbook* increase the habitat value of streams for listed fish species by decreasing sedimentation of streams, increasing the quality of the riparian corridor, and improving instream habitat. A marketing component designed to increase the value of wine produced by these growers gives a financial incentive to certified growers and is likely to increase the level of success of this program. Additional financial assistance for restoration efforts would be sought.

5.5.9.7 Palmer Road Erosion Control

In addition to reducing sediment input from a mile of steep rural roadway, this project has value as a demonstration project for effective rural road erosion control. Application of these techniques to other rural roads in the watershed could substantially reduce erosion in this basin.

5.5.9.8 Federal and State Recovery Planning

SCWA is providing staff and substantial financial support for federal and state recovery planning efforts. As of the end of 2003, SCWA has allocated $4.6 million for recovery planning. These efforts are vital to coho salmon recovery. Coordination of recovery efforts throughout the basin and within the ESU would focus scarce resources where they are likely to do the most good. This is likely to improve metapopulation structure of existing populations and result in increased chances of long-term survival of the species.

5.5.9.9 Invasive Plant Species

Non-native plant species have the potential to seriously impair the natural functions of the Russian River ecosystem. Of particular concern is *Arundo donax.* Information about the influence of invasive weeds on native riparian vegetation and insects is needed to assess the effects on the aquatic ecosystem that supports coho salmon, steelhead, and Chinook salmon. By funding studies, developing effective control measures, and controlling *Arundo* while it is still manageable, SCWA is working to prevent the devastating level of infestation that occurs in streams in southern California.

The extent of *Arundo* infestation has been determined and mapped. Many areas in the Alexander Valley have been dominated by *Arundo* (Natural Resources Management Corporation 1999). These could serve as source populations from which downstream areas are colonized. Identification of areas where *Arundo* has taken hold is an important first step in the effort to control it.

Arundo removal and establishment of native riparian vegetation is an important conservation action that could have significant localized effects throughout the river basin. Therefore, the biological benefit score is 5 (Table 5-71). *Arundo* is generally removed with a combination of mechanical means and application of an herbicide approved for aquatic use. As eradication efforts target non-native vegetation, and the herbicide is applied by trained personnel, the benefits of *Arundo* eradication far outweigh minimal risk of short-term effects that may occur from herbicide use (Table 5-72). As *Arundo* is very difficult to eradicate, research that could identify effective methods for restoring *Arundo* patches to native vegetation would be invaluable.

Because *Arundo* is available in nurseries, educating the public about *Arundo* and coordinating volunteer efforts for its removal is an important component of an effort to eradicate this invasive weed and prevent its spread or reintroduction. SCWA distributes a native riparian plant handbook to assist individuals and groups, and this information will help control the spread of invasive species. SCWA is taking a watershed approach to the control of non-native weeds because a basinwide effort is needed to keep *Arundo* under control.

Table 5-71 Non-Native Vegetation Removal Biological Benefit Score (*Arundo donax*)

Category Score	Evaluation Criteria Category	Project Score*
5	Very high potential to benefit.	Co, St, Ch
4	High potential to benefit.	
3	Moderate potential to benefit.	
2	No benefit and uses scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

Table 5-72 Vegetation Control Score for *Arundo donax*

Category Score	Evaluation Criteria Category	Project Score*
5	No chemical release.	
4	Limited use of herbicide approved for aquatic use in riparian zones or over water.	
3	Moderate to heavy use of herbicide approved for aquatic use in riparian zones or over water.	Co, St, Ch
2	Use of herbicide not consistent with instructions.	
1	Use of herbicide not approved for aquatic use in riparian zones or over water.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.10 Riverfront Park Reclamation

A property recently acquired by SCWA is to be restored as Riverfront Park. Three former gravel mining pits located on the property have filled with water and are now referred to as Lake McLaughlin, Lake Wilson, and Lake Benoist. These lakes have the potential to entrain salmonids when floodwaters recede after high-flow events. The property is located in the Lower Russian River and adult and juvenile salmonids of all three listed fish species may be affected.

Floodwater can flow through an opening in the riverbank upstream of the property at the Doyle Pit (elevation 63.5 feet NVGD and a 1.75-year return interval) and enter Lake McLaughlin, providing a conduit for fish passage to the lake. Floodwater can overtop the banks on the northwest side of the property (2-year return interval). Flow can back up through a rock riprap weir at the southern end of Lake Benoist and flow to Lake Wilson. When waters are high enough (60.5 feet NVGD), water can flow between Lake Wilson and Lake McLaughlin (1.25-year return interval). At high flood flows, the entire area can be under water (10-year flood event). When floodwaters recede, water drains back to the river through the weir at the southern end of the property (53 feet NVGD). Fish passage back to the river over this weir is only available as long as water flows over it. Fish passage from Lake McLaughlin is available when water flows between Lake Wilson and Lake McLaughlin.

During the summer, some of the lake water seeps back to the river. However, the lakes retain water all year and the deepest lake has a depth of over 50 feet.

Salmonids migrating or rearing in the vicinity can be entrained into these lakes. Once flood flows recede, no passage out of the area is available. The lakes are too large and deep to conduct effective fish rescue. Steelhead trapped in the lake are likely to revert from the anadromous to resident form of trout and may be subject to fishing pressure. Coho and Chinook salmon trapped in the lake are likely to be lost to the effective population. These risks associated with entrainment were present even before SCWA acquired the property.

The risk of entrapment is based upon opportunity for escape or rescue. Passage past the lakes is also evaluated for the opportunity for entrapment or injury based on the amount of streamflow diverted and the amount of time water is diverted during a species life-history stage. Finally, the risk of predation to salmonids in the river if predators from the lake are released is evaluated.

5.5.10.1 Risk of Entrapment

The lakes flood when river flows overtop the banks. Fish passage is not available after flood flows recede, and fish rescue is infeasible. Salmonids entrained in the lake are likely to be lost to the listed anadromous population. The opportunity for entrapment is based in part on how much water is diverted and how often the water is diverted. There are no estimates of the percentage of flow that is diverted during high flows, but it is assumed that it can be a significant volume. Flood flows can enter Lake McLaughlin on a return interval of 1.75 years, so only a small portion of the migration period is likely to be affected. Applying evaluation criteria for the amount of time water is diverted, the score is 4 (Table 5-73).

Migrating salmonids that are passing through during one of these flood events have a high risk of being entrained, but one of these events only occurs about once every 1 or 2 years. The park property is located in the Lower Russian River and juvenile salmonids of all three species that migrate from upstream areas during one of these events are at risk. Upstream adult migrants may also be entrained.

Table 5-73 Passage Scores for Juvenile Salmonids – Opportunity for Entrapment, or Injury at Riverfront Park Lakes –Time Water is Diverted

Category Score	Evaluation Categories	Current Operations Score*
5	Facility does not affect surface water flow during any time of migration period.	
4	Facility diverts surface flow during less than 10% of migration period.	Co, St, Ch
3	Facility operates between 10% and 15% of migration period.	
2	Facility operates between 15% and 25% of migration period.	
1	Facility operates during more than 25% of the migration period.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

5.5.10.2 Predation

These lakes may create warmwater habitat for fish species that prey on salmonids. There already are self-sustaining populations of the warmwater fish communities in the Lower Russian River. If predators are released from the Riverfront Park lakes, warmwater fish populations could be supplemented in the Russian River. Fish passage from the lakes is only available during high-flow events, so predators have limited opportunities to enter the river. Furthermore, during the high-flow season, river conditions are not favorable to non-native warmwater fish species. High summer water temperatures are likely to limit the quality of summer rearing habitat for salmonids in the vicinity, but the lakes are located in the Lower Russian River, and downstream migrants from the watershed upstream would pass through the area. However, because there already is a warmwater fish community established in the vicinity, these lakes are not likely to introduce a new or substantial risk of predation to migrating or rearing salmonids.

5.5.11 Water Conservation and Recycled Water

SCWA plans to undertake water conservation measures that will reduce demands on SCWA's water transmission system. This program is designed to reduce peak water demands, which typically occur during the dry season in mid-summer. Water reuse and conservation could reduce peak water demand from 3 to 5 percent. Water conservation is expected to help meet future, growing, water demands and may help to reduce the amount of water diverted from streams.

5.6 FISH FACILITY OPERATIONS

This section evaluates effects on the three salmonids for each of three proposed hatchery programs: an isolated steelhead harvest program; an integrated coho recovery program using captive broodstock; and a "no production" option for Chinook salmon. This discussion is organized into categories that encompass functional requirements of hatchery production. Following each hatchery operations category, a table is presented that ranks the risk posed by each of the three hatchery programs. Evaluated effects include water quality, water quantity, and genetic and ecological risks associated with hatchery production. There is also an assessment of benefits that should arise from implementation of the three proposed programs.

The Section 7 Consultation between NOAA Fisheries, USACE, and SCWA addresses a time-frame extending well beyond the 2007 expiration of the current coho salmon captive broodstock pilot program. In light of current low numbers of coho salmon in the Russian River basin and in anticipation of information to be collected from the pilot program, this analysis evaluates a captive broodstock program and a supplementation program utilizing capture of adults. The objectives of the proposed coho program are to 1) prevent extirpation of Russian River coho salmon, 2) preserve genetic, ecological, and behavioral attributes of Russian River coho salmon while minimizing potential impacts to other stocks and species, and 3) build a naturally-sustaining coho salmon population.

This section also evaluates the effects of the proposed isolated harvest program for steelhead and the proposed "no production" program for Chinook salmon. The justification for the steelhead program is to provide mitigation for loss of habitat resulting from construction of Warm Springs Dam and Coyote Valley Dam, incorporating measures as necessary to minimize negative effects on listed fish species. The justification for the "no production" program for Chinook salmon is to eliminate any potential negative effects to listed fish populations that may arise from non-essential hatchery activities.

Information presented in Appendix C, and FishPro, Inc. and ENTRIX, Inc. (2002) described the genetic and ecological risks of hatchery production with respect to the major theoretical and observed effects to wild salmonid populations. There was also discussion of the general hatchery practices and management decisions that have potential to affect each risk issue. Data are currently being collected that will provide a greater understanding of the status and genetic characteristics of naturally-spawning steelhead and Chinook salmon in the Russian River basin. Depending on the results of those data collection efforts, it may be more appropriate to conduct an integrated harvest program for steelhead, and/or an integrated recovery (supplementation) program for Chinook salmon. This section consequently evaluates those two programs as future alternative programs for steelhead and Chinook salmon.

5.6.1 Evaluation of Effects of Proposed Fish Facility Programs on Listed Species

5.6.1.1 Water Quality

Effluent water quality discharge limits have been established by the NCRWQCB to meet beneficial uses of the receiving waters. For DCFH, this includes Dry Creek and the Russian River. At CVFF, the beneficial uses are established for the East Fork Russian River below the outfall and the mainstem Russian River. Beneficial uses for both sites are the same and include the following uses applicable to the target species of this evaluation: cold freshwater habitat; preservation of rare and endangered species; fish migration; and fish spawning (NCRWQCB 1997a, 1997b). The daily maximum effluent limits established in the permits are created to meet these beneficial uses and allow for either a minimal acceptable change or no change to the receiving waters.

Discharge standards for the Russian River fish production facilities are specified in the following NPDES permits issued by the NCRWQCB:

- Don Clausen Fish Hatchery: Order No. 97-61, NPDES Permit No. CA0024350 (NCRWQCB 1997a).
- Coyote Valley Fish Facility: Order No. 97-60, NPDES Permit No. CA0024791 (NCRWQCB 1997b).

The permits require that the facilities be equipped with waste treatment equipment to ensure compliance with specified water quality criteria (Table 5-74). The key piece of equipment at DCFH is an in-line earthen settling pond that provides solids removal treatment of the entire hatchery discharge, while CVFF is equipped with an off-line concrete settling basin that treats only the wastes generated during raceway cleaning. Compliance with discharge standards is monitored by sampling the facility effluent two times per month, with results submitted in a monthly report to the NCRWQCB. Sampling must occur during cleaning operations, because this is the aspect of fish production that is most likely to produce poor water quality conditions.

Table 5-74 Discharge Standards for DCFH and CVFF

Parameter	Effluent Limit (Daily Maximum)
Total Suspended Solids	15 mg/l
Total Settleable Solids	0.2 ml/l/hr
pH	within 0.5 of receiving waters
Salinity (chloride)	250 mg/l
Temperature	no measurable change to receiving water
Turbidity	no increase > 20% of background
Dissolved Oxygen	> 7.0 mg/l
Flow – DCFH	15.5 mgd
Flow – CVFF	7.11 mgd

The discharge permits include operational stipulations in addition to the monthly monitoring noted above. For example, direct discharge of wastes from pond cleaning and the bypass of wastes around the pollution control pond are prohibited. At DCFH, it is prohibited to discharge detectable levels of chemicals used for the treatment or control of disease, other than salt (sodium chloride).

Both DCFH and CVFF have been in continuous compliance with their NPDES permit requirements (Table 5-75) (R. Gunter, CDFG, pers. comm. 1999). During times of high turbidity in the influent water, the hatchery may actually discharge water less turbid than that received, thereby benefiting the receiving waters. The DO level in the receiving waters during times of low flows may drop below the 7-mg/l limit and therefore may benefit from the hatchery maintaining a > 7-mg/l effluent limit. Effluent from the hatchery will contribute to the total load of solids in the receiving waters. The settleable and suspended solid levels discharged are slightly higher than incoming water, but are within the limits of the NPDES permits (R. Gunter, CDFG, pers. comm. 1999).

Table 5-75 Water Quality Evaluation Criteria and Scoring for Salmonids

Category Score	Evaluation Criteria Categories	Score
5	Continuous compliance with NPDES standards.	Co, St, Ch
4	Compliance with 75-99% of standards.	
3	Compliance with 50-74% of standards.	
2	Compliance with 25-49% of standards.	
1	Compliance with 0-24% of standards.	

Co = Coho salmon, St = Steelhead, Ch = Chinook salmon

Proposed changes to the DCFH water supply system will increase the facility flow capacity to 50 cfs (32.3 mgd) (see Section 4.6.5.1). Increasing the flow rate through the settling pond may affect the solids removal efficiency of the treatment system, although the very large size of the settling pond and its past effectiveness suggest there will be negligible impact to the solids removal efficiency. At the same time, the proposed DCFH production program will reduce the total annual solids loading into the settling pond to approximately 74 percent of the solids loading which occurred under the baseline production goals. The combined effect of these two factors is expected to result in facility discharge solids loadings that are equal to or less than baseline loadings, and instantaneous solids concentrations that are significantly less than baseline conditions. Implementation of the DCFH water supply modifications project will require an amendment of the NPDES permit (since the existing permit limits the maximum flow to 15.5 mgd), and a rigorous engineering evaluation will be conducted as part of the NPDES amendment process to ensure that water discharge standards are satisfied under the modified conditions.

In the interim period before modification of the water supply system, the water quality of the DCFH effluent is not likely to significantly degrade water quality in Dry Creek or the Russian River, based on the past compliance with discharge standards and the reduced solids loading expected under the proposed production program. At CVFF, which will continue the same production program as occurred during the baseline, the past compliance with its NPDES discharge permit indicates the water quality of the CVFF effluent is not likely to significantly degrade water quality in the East Fork Russian River or the mainstem Russian River.

5.6.1.2 Water Quantity

The total hatchery water demand at DCFH for full-capacity fish production operations is 25 cfs. When broodstock collection and holding operations are occurring, the demand increases to approximately 35 cfs to provide attraction flows for adult fish migrating upstream and to provide flows to maintain the fish in holding ponds once they enter the hatchery. The emergency water supply is in fully charged condition. However, hatchery staff are required to contact USACE to open the valve for access to the emergency water supply, and delays are possible. As water demand increases for the coho captive broodstock program over the next several years, it is important that an increased and reliable source of water be available.

The new water supply line proposed for the DCFH will tap into the existing wet well and provide a single pipeline capable of delivering 50 cfs of gravity-flow reservoir water to the DCFH facilities. This new water-supply line will provide a reliable and sufficient water source. A feasibility study to evaluate the most appropriate design of the water supply line will be completed in 2004, and construction of the modifications may be complete by 2007. Interim water supply needs will be supplemented by installing pumps in Lake Sonoma, if necessary.

The configuration of the water supply intake location with respect to the facility effluent discharge location at DCFH results in a bypass reach of approximately 900 feet for which the hatchery flow rate is diverted from the instream flow of Dry Creek. At CVFF, a similar bypass reach exists for approximately 950 feet of the East Fork Russian River immediately below Coyote Valley Dam. These bypass reaches are acknowledged and accommodated through minimum streamflow provisions contained in D1610 (see Section 1.4.3).

5.6.1.3 Genetic and Ecological Effects

This section presents an analysis of the risks and benefits for each species associated with implementation of the proposed fish facility programs. The potential risks of hatchery production to listed species fall into two areas, genetic risks and ecological risks. Genetic risks may include loss of diversity within and between populations, outbreeding depression, and inbreeding depression. Ecological risks to listed species may include increased competition for food, habitat or mates; increased predation; disease transfer; altered migration behavior; long-term viability; artificial selection; disproportional survival; and harvest bycatch. These risks and the associated hatchery operations that may contribute to each risk are summarized in Table 5-76 and discussed below.

Table 5-76 Hatchery Production Risks to Wild Salmonids and the Associated Hatchery Operations that May Contribute to Each Risk

Hatchery Production Risks to Wild Salmonids	Hatchery Operations That May Contribute to Each Risk						
	Source of Broodstock	Number of Broodstock Collected	Broodstock Sampling and Mating	Rearing Techniques	Release Strategies	Duration in Hatchery Captivity	Harvest Management
Genetic Risks							
Loss of Within-Population Diversity	X	X	X	X		X	
Loss of Between-Population Diversity	X				X		
Outbreeding Depression	X		X				
Inbreeding Depression	X	X					
Ecological Risks							
Competition					X		
Predation					X		
Disease Transfer				X			
Outmigration Behavior					X		
Long-Term Viability				X			
Artificial Selection	X			X		X	
Disproportional Survival		X	X				
Harvest Bycatch							X

In the following section, these hatchery practices are described as they apply to the proposed coho salmon, steelhead, and Chinook salmon production programs for the Russian River fish facilities. Due to the diversity of hatchery operations, this discussion is organized into seven categories that encompass functional requirements:

- Sources of Broodstock
- Numbers of Broodstock
- Broodstock Sampling and Mating Protocols
- Rearing Techniques
- Release Strategies
- Duration in Hatchery Captivity
- Harvest Management

Sources of Broodstock

<u>Coho Salmon</u>

Some genetic data are available for coho salmon spawning aggregates within the Russian River and surrounding basins. The following summary is based on data analyzed by various management agencies, as presented at the Russian River Coho Recovery Work Group meetings and described in greater detail in Section 2.2.5 of this report. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins and the following preliminary conclusions:

- Samples from Green Valley, Mark West, and Maacama creeks cluster unambiguously. These samples are very different from Russian River hatchery samples and from Olema Creek (Hedgecock et al. 2003; Garza and Gilbert-Horvath 2003).

- Green Valley samples exhibited a high degree of relatedness, suggesting that there is a substantial risk of inbreeding if these fish are used as a source of broodstock.

- Both Lagunitas and Russian River samples show signs of inbreeding.

The existing Russian River Coho Recovery program implemented broodstock collection efforts in 2001 and 2002. More than 300 coho salmon juveniles were collected each year for captive rearing from several locations as noted in Table 5-77.

Table 5-77 Juvenile Coho Salmon Collected for Russian River Captive Broodstock

Year	Total	Olema	Russian River Sources
2001	304	120	Mostly Green Valley
2002	459	150	Green Valley, Mark West, Dutch Bill

Source: Russian River Coho Enhancement Monitoring and Evaluation Subcommittee (2/27/03)

The risk of eroding between-population diversity can be controlled by: 1) maximizing the contribution of locally-derived juveniles and adults in the broodstock, and 2) minimizing the probability of straying. Given that preliminary genetic data suggest the presence of stock structure within the Russian River, erosion of this stock structure could occur if managers propagate a composite stock of coho salmon, and outplant their progeny throughout the basin. However, the risk of inbreeding depression, which might result from an attempt to propagate multiple stocks of very small size, may outweigh the risks of homogenization, particularly if the observed stock structure is the result of bottlenecks, or extreme genetic drift, resulting from high mortality and small population size. The available data are insufficient to adequately assess whether homogenization presents a lower risk than propagation of many small stocks. However, given the difficulty encountered in collecting large numbers of juvenile coho salmon, the use of a composite stock may be unavoidable.

NOAA Fisheries is conducting a genetic analysis of the fish collected for the captive broodstock program to add to the understanding of the population structure of local coho salmon stocks and to facilitate program breeding decisions. These data will be used to evaluate the relative risks of inbreeding and outbreeding depression as the capture, mating, and release protocols are developed for the captive broodstock program.

The source of broodstock used in hatchery operations has the potential to affect the wild population, primarily through the mechanism of outbreeding depression. Depending on specific circumstances, the source of broodstock also has potential to contribute to loss of within-population or between-population diversity, inbreeding depression, or straying of the hatchery-reared component. However, by utilizing local stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component is presumably identical to that of the wild population. Because the abundance of local stocks are insufficient to meet the broodstock demand, then the priorities noted by FishPro and ENTRIX, Inc. (2002) can provide the basis for selecting alternative sources while minimizing risk to the wild population. Table 5-78 gives the scores for the coho captive broodstock program for the early (score of 4) and later (score of 5) stages. Due to the inability to locate sufficient numbers of coho salmon within the Russian River basin, the first-year implementation of the current coho recovery program obtained approximately one-third of the broodstock from Olema Creek in the adjacent Lagunitas watershed. Subsequent years of collection will attempt to increase the proportion of broodstock collected from the Russian River basin.

Table 5-78 Source of Broodstock Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Local broodstock source (target stock), collected in the most unbiased manner possible.	Coho supplementation or captive brood (later stages). Chinook “no production.”
4	Naturally-spawned broodstock source from the nearest watershed; or a combination of naturally-spawned and hatchery-reared broodstock from the local source.	Coho supplementation or captive brood (earliest stages).
3	Hatchery-reared broodstock source from the local or nearest watershed; or naturally-spawned broodstock source from within the same ESU.	Steelhead isolated harvest.
2	Hatchery-reared broodstock source from within the same ESU; or naturally-spawned broodstock source from a different ESU.	
1	Hatchery-reared broodstock source from a different ESU.	

Steelhead

The isolated harvest program would derive all broodstock from the supply of adult steelhead returning to the hatchery. DCFH steelhead were not listed as part of the Central California Coastal (CCC) Steelhead ESU because information concerning the hatchery stock is sparse, and therefore the stock’s relationship to the entire ESU is uncertain.

Fortunately, some genetic data are available for steelhead spawning aggregates within the Russian River and surrounding basins. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins and the following preliminary conclusions:

- There is a large relative magnitude of diversity among steelhead populations in California, particularly south of the Klamath River.
- Samples from south of the Eel River form a genetically diverse cluster that joins the other West Coast steelhead populations, apart from the inland clusters.
- Although steelhead in California are more similar to other coastal populations than to inland steelhead from the Columbia River basin, there is a great deal of diversity in the coastal steelhead groups.
- Historic stock transfers may have introduced divergent lineages into hatchery stocks, as evidenced by the greater number of mtDNA types found in hatchery stocks of steelhead as compared to geographically proximate wild populations (Nielsen 1994).

The source of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanism of outbreeding depression. Depending on specific circumstances, the source of broodstock also has potential to contribute to loss of within-population or between-population diversity, inbreeding depression, or straying of the hatchery-reared component. Historically, outplanting occurred using broodstock from out-of-basin sources, but since 1990, all steelhead releases are progeny of broodstock collected from within the basin. The source of genetic material in the hatchery component may be similar to that of the wild population. Currently, no broodstock are collected from the natural population; only hatchery-origin fish are used in the spawning protocol. A score of 3 is given for broodstock for the steelhead isolated harvest program (Table 5-78).

Chinook Salmon

Some genetic data are available for Chinook salmon spawning aggregates within the Russian River and surrounding basins. The following summary is based on data analyzed by various management agencies and by researchers at the Bodega Marine Lab. In general, existing genetic data support the current ESU designation for the Russian River and surrounding basins, and the following conclusions:

- Fall-run Chinook salmon in the California Coastal ESU are generally distinct from populations in adjacent ESUs, with the possible exception of fall-run Chinook from Blue Creek, in the lower Klamath River (Banks et al. 1999).
- Genetic data indicate naturally-spawned Chinook salmon from the Russian River are more closely related to coastal Chinook from the Eel and Klamath rivers than to inland populations (Central Valley and Santa Clara Valley). However, samples from the Eel and Russian rivers are not closely related. The Russian River

population belongs to a diverse set of coastal Chinook salmon populations (Hedgecock et al. 2003).

- Given the magnitude and duration of historic interbasin stock transfers in the Russian River, the naturally-spawning population documented in recent years may be a conglomerate of many stocks.

Although there has been some debate regarding the historical presence of Chinook salmon in the Russian River, the naturally-reproducing population is protected under the ESA. The "no production" program does not affect the local broodstock, and therefore a score of 5 is provided (Table 5-78).

Numbers of Broodstock

<u>Coho Salmon</u>

Given that the Russian River coho program is intended for short-term conservation and long-term restoration, escapement and broodstock goals are based on probabilities associated with maintaining genetic variation, and limiting demographic risks, both to the hatchery-reared and naturally-spawned components of the Russian River coho salmon population(s). In general, the escapement and broodstock goals are formulated to provide for "genetic and life-history redundancy," that is to say if a brood year is lost in the hatchery or in the stream, the surviving component should maintain sufficient genetic and life-history variation to maintain the stock. To reasonably ensure this redundancy requires that the hatchery-spawning and naturally-spawning population components are representative of one another, both genetically and in life-history characteristics, and that both components are maintained at a large size, which may be unrealistic in the short-term.

Instream spawning and broodstock goals are formulated to provide a 95 percent probability of retaining alleles occurring at a frequency of 1 percent or greater within each component of the Russian River population for a period of 5 coho salmon generations (15 years). Approximately 400 adult spawners are required in each environment to meet this goal (see FishPro and ENTRIX, Inc. 2003). Assuming a pre-spawning mortality of 5 percent, approximately 420 adults are required for instream spawning, and an additional 420 adults are required for broodstock. If juveniles are collected to form a captive brood, juvenile collections would have to be substantially larger to provide 420 adults for broodstock. Assuming a 40 percent fry-to-adult survival rate[1] in captivity (Arkush et al. 1997), approximately 588 fry would be required to achieve the adult spawning goal within the hatchery.

Using the escapement estimates of 420 spawners in each environment, and assuming an adult return rate of 0.5 and 4, respectively, for instream and hatchery-spawners, contribution to the next generation would be 210 and 1,680 adults of natural and hatchery

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[1] Juvenile collection thus far has focused on more advanced life-history stages. Fry survival estimates were used to provide a conservative estimate.

origin, respectively, with a combined N_b of 168. Ultimately, for reasons relating to artificial selection, it would be appropriate to maintain a minimum escapement goal that would allow for collection of broodstock solely from naturally-spawned adults. With a natural return rate of 0.5, this would require instream spawning by a minimum of 840 adults (which could be a combination of natural-origin and hatchery-origin individuals). Therefore, assuming 5 percent pre-spawn mortality in each environment, a minimum escapement of 1,322 adults per year is required.

Although the current Russian River coho salmon program is based on captive broodstock derived from juvenile collections, the adult escapement estimates formulated above are still valid. For example, if juveniles for the captive brood are collected solely from natural spawners, but adult escapement is low, the probability of sampling the progeny of only a few adults increases dramatically. Under this scenario, inbreeding could be expected to increase rapidly.

The numbers of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanisms of inbreeding depression and loss of within-population diversity. However, by determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect is minimized. Table 5-79 organizes the potential range broodstock availability into five categories and provides a score of 3 for the early stages of the coho program and a score of 5 for the later stages.

Table 5-79 Numbers of Broodstock Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Maintenance of N_b necessary to maintain genetic variation with a 95% probability, in both instream and hatchery components.	Coho supplementation and captive brood (later stages). Chinook “no production” (current estimate).
4	Instream escapement > 50% N_b and hatchery broodstock > 75% N_b.	Steelhead isolated harvest.
3	Instream escapement < 50% N_b and hatchery broodstock > 50% N_b.	Coho supplementation and captive brood (earlier stages).
2	Instream escapement < 50% N_b and hatchery broodstock < 50% N_b.	
1	Instream escapement < 50% N_b.	

This assessment has estimated that a minimum of 840 wild, instream spawners is necessary if genetic variation is to be maintained over a period of 15 years. Based on the extremely low incidence of observed presence of coho salmon adults in the Russian River in recent years, it is believed there is less than half this number spawning naturally. This estimate suggests very strongly that a “no production” alternative for coho salmon would result in genetic effects to the remaining Russian River coho salmon population, and it further suggests that a supplementation program is needed to attempt recovery of the species. It may also be necessary to implement stream restoration programs to provide habitat sufficient for supporting 840 fish.

Implementation of a supplementation or captive brood program will provide an increased survival advantage of the early hatchery-reared lifestages that allows the number of spawners to be reduced to 420 while still maintaining the same threshold of genetic variation. Due to additional pre-spawning mortality that is inevitable with a captive brood program, it is estimated that 588 fry would need to be collected to achieve the minimum broodstock number. In its first year of implementation, the coho captive broodstock program collected more than 300 fry, suggesting there may still be some risk associated with genetic effect. It is expected that minimum broodstock thresholds would be achieved for both the hatchery and instream components 2 years following the first smolt release under the supplementation or captive brood production alternatives.

Steelhead

Benefit/risk analyses conducted for Russian River hatchery operations (FishPro and ENTRIX, Inc. 2003) suggest a minimum broodstock number of 210 spawners for an isolated steelhead harvest program. Escapement and broodstock goals for a Russian River steelhead program have been based on probabilities associated with maintaining genetic variation, and limiting demographic risks, both to the hatchery-reared and naturally-spawned components of the Russian River steelhead population(s). Hatchery broodstock goals are formulated to provide a 95 percent probability of retaining alleles occurring at a frequency of 1 percent or greater for a period of 3 steelhead generations (15 years). Because the proposed steelhead program is an isolated program, both the hatchery and wild populations must have the minimum number of broodstock necessary to maintain the genetic variability in each component of the population. From 1981 to 2003, the average annual adult return of steelhead to the DCFH was 2,147 fish, with a peak return of 8,100 fish during the 1994-95 season (see Section 3.8, Table 3-24, History of Steelhead Trapped at DCFH and CVFF). At the CVFF, the average annual steelhead return has been 1,991 fish, with a peak return of 3,735 fish occurring in 1996-97 (see Table 3-24). Returning steelhead numbers to both DCFH and CVFF are high enough that the probability of inbreeding within the hatchery population is low.

Adult fish counts collected through video monitoring at the Mirabel inflatable dam observed no wild steelhead during the 1999 and 2001 study periods, 36 wild steelhead during the 2002 study, and 110 wild steelhead during the 2000 study (Chase et al. 2000, 2001, 2002, 2003). Based on these observed counts, there is some uncertainty whether the Russian River system currently supports the minimum number of wild steelhead necessary to maintain diversity within the wild population. However, monitoring at the dam generally occurs over only a small portion of the steelhead run and these data are not likely to reflect the actual size of the run. Furthermore, 2000 was a dry year, and monitoring was discontinued before substantial flows occurred.

Population monitoring was conducted in Santa Rosa and Millington creeks over 3 years (Cook and Manning 2002, SCWA 2002). In general, population trends from 1999 to 2001 showed a peak in 2000, with relatively lower numbers observed in 1999 and 2001. This trend was likely affected by annual rainfall.

A conservative course of action would assume that the effective number of wild steelhead spawners occurring in the Russian River is insufficient to maintain genetic variation, and that inbreeding depression and loss of within-population diversity may be occurring in the Russian River wild steelhead population, at least until such time it can be shown that the wild steelhead population level is at or above the minimum broodstock threshold. An integrated program that would utilize naturally-spawning steelhead as broodstock could supplement the wild population and increase the number of effective spawners more quickly than without a supplementation program (evaluated in Section 5.6.5). Therefore, the risk to the genetic integrity of the wild population would be greater for an isolated program and less for an integrated program. Table 5-79 organizes the potential range of broodstock availability into five categories and provides a score of 4 for the relative risk level for the steelhead isolated harvest program.

Chinook Salmon

To formulate escapement goals for Chinook salmon in the Russian River, an estimate is made of the number of adults per year required to maintain a 95 percent probability that alleles occurring at a frequency of 1 percent or greater would be retained for a period of 15 years. An estimated minimum broodstock threshold of 242 spawners is necessary if genetic variation is to be maintained over 15 years in the naturally-spawning population (see FishPro and ENTRIX, Inc. 2003). SCWA data documented naturally-spawned Chinook salmon adults that passed the Mirabel inflatable dam, with a run-count of 1,322 during the 2000 study period, a partial run-count of 1,300 during the limited 2001 study period, and a run-count of 5,466 in 2002 (Chase et al. 2001, 2002, 2003). Based on these data, it appears likely that the Russian River system currently supports the minimum number of wild Chinook salmon necessary to maintain diversity within the wild population. These numbers suggest that the “no production” program is not likely to result in genetic effects to the remaining Chinook salmon population. Table 5-79 organizes the potential range of broodstock availability into five categories and provides a score of 5.

Broodstock Sampling and Mating Protocols

Maintaining genetic characteristics of a population during artificial propagation may be affected by the manner in which the broodstock are mated. The mating protocols recommended by NOAA Fisheries (Hard et al. 1992) were outlined in FishPro and ENTRIX, Inc. 2003. Broodstock sampling and mating protocols have the potential to affect the wild population, primarily through the mechanisms of loss of within-population diversity and outbreeding depression.

Coho Salmon

Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a score of 2 for the early stages of the coho program and a score of 3 for the later stages.

The current status of coho salmon presence in the Russian River basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating. This condition may exacerbate the potential of sibling mating within the wild population. For the proposed supplementation and captive broodstock programs, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population. A sliding schedule for mating would be established that would use diallel mating, systematic mating, or single-pair mating, depending on the number of adult returns.

Table 5-80 Broodstock Sampling and Mating Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	Large naturally-spawning component allowing random mating.	Chinook "no production" (current estimate).
4	Large broodstock with pedigree mating.	
3	Large broodstock with random mating; or medium broodstock with pedigree mating.	Steelhead isolated harvest. Coho supplementation and captive broodstock (later stages).
2	Medium broodstock with random mating; or small broodstock with pedigree mating.	Coho supplementation and captive broodstock (earlier stages).
1	Random mating precluded in naturally-spawning component (due to small population size and/or isolation).	

Steelhead

Spawning protocols provide for the representation of returning fish over the complete spectrum of the spawning run (steelhead are selected systematically across the entire adult return). Jacks will be incorporated in a proportion based on their occurrence in the run. In addition, surplus eggs are taken, from which a random sample will comprise the harvest for each week. This strategy will continue to be employed to decrease the loss of genetic diversity. Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a score of 3 for the risk level for an isolated harvest program.

The current status of steelhead in the Russian River basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating. This condition may exacerbate the potential of sibling mating within the wild population. Due to mass marking of hatchery fish, it is possible to distinguish between hatchery and wild progeny. The return of natural fish to the river where they may spawn naturally has decreased the risk of possible genetic effects due to hatchery broodstock collection.

Chinook Salmon

The current status of Chinook salmon in the Russian River basin should allow for random mating, although it is unknown whether the Russian River supports distinct or isolated spawning aggregates having population sizes less than the recommended minimum broodstock number. This condition may exacerbate the potential of sibling mating within the wild population. Table 5-80 organizes the potential range of sampling and mating procedures into five categories and provides a program score of 5.

Rearing Techniques

Naturalized Rearing Environments

One approach for decreasing the potentially deleterious effects of artificial selection is implementation of the Natural Rearing Enhancement System (NATURES) described by Maynard et al. (1996). While implementation of these methods may not increase survival per se, implementation of NATURES methods might be useful as a means to avoid cryptic side effects of artificial selection.

Rearing techniques have the potential to affect the wild population primarily through the mechanism of artificial selection. Environmental conditions in the hatchery that attempt to simulate natural conditions are likely to reduce typical differences between hatchery and natural fish. Low-density rearing indices (between 0.30 and 0.40 pounds of fish per cubic foot [lbs/cf] of water per inch of fish length) are recommended by NOAA Fisheries as a means to maximize adult return (Flagg et al. 2000).

Although "natural" rearing methods have not been significantly adopted at DCFH or CVFF, routine operations of these facilities already include some of the recommended procedures: broodstock selection, shaded ponds at DCFH, volitional release at CVFF, imprinting at both facilities, health monitoring, release timing coordinated with smoltification and lunar phase, and daily exercise encountered during cleaning operations when water velocities are much greater than the normal condition. Photoperiods of outdoor rearing facilities (containing salmonids ranging in size from fingerlings to smolts) follow the natural environment at both facilities.

Table 5-81 organizes the potential range of rearing techniques into five categories and provides each program with a score of relative-risk level. Rearing pond densities are usually managed to maintain a maximum density of 2.25 lbs/cf. For the steelhead isolated harvest program, the score is 2. At a minimum, it is expected that coho supplementation and captive brood programs would operate under low-density conditions, and that NATURES features would be added as data become more conclusive regarding their benefit to minimizing artificial selection and increasing adult return. Rearing ponds for coho salmon to be released will be managed so they do not exceed a maximum density of

2.25 lbs/cf. Lower densities will be maintained whenever possible. Rearing pond densities for the captive broodstock will be managed so they do not exceed a maximum density of 1.0 lbs/cf. For the coho program, the score is 3. Because there is no hatchery captivity, there is no risk for Chinook salmon.

Table 5-81 Rearing Techniques Evaluation Criteria and Scoring for Coho Salmon, Steelhead, and Chinook Salmon

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	Chinook "no production."
4	Low-density rearing with multiple NATURES features.	
3	Low-density rearing.	Coho supplementation, captive brood.
2	High-density rearing with NATURES features.	Steelhead isolated harvest.
1	High-density rearing.	

Fish Health

As compared to the low fish densities observed in wild populations, the higher density conditions of artificial propagation increases the risk of prevalence of fish pathogens that are present naturally in the watershed. Pathogens that are capable of establishing carrier states and can be transmitted vertically with gametes, such as bacterial kidney disease and bacterial coldwater disease, are of particular concern for supplementation programs because of the potential to create a disproportionate carrier rate among hatchery-reared fish. The potential effects extend into the future by perpetuation of the pathogens by vertical transmissions from the F1 (first generation) hatchery-reared fish to their F2 (second generation) naturally-spawning progeny (Hedrick 2002).

As a means of minimizing the risk of disease transfer to the wild population, CDFG conducts routine fish health management operations at all of its facilities, including DCFH and CVFF. These operations include the following fish health protocols recommended by NOAA Fisheries (Hard et al. 1992):

- Adults contributing gametes are regularly sampled for pathogens of common salmonid diseases.

- Incubation facilities are sterilized before gametes are transported to them.

- Gametes brought into the facility are isolated from all others and the resulting fertilized eggs disinfected. To avoid horizontal disease transfer, progeny should be isolated by full-sib family until cleared though pathological testing and then monitored regularly during culture.

- Infected fish are isolated and treated. However, it should be recognized that some incipient level of disease is natural and also probably essential for immunological readiness for episodic outbreaks.

The DCFH hatchery water supply is treated to minimize the transfer of pathogens from the natural population. Details regarding DCFH and CVFF fish health practices are outlined in the HGMPs (FishPro, Inc. and ENTRIX, Inc. 2003). The facilities maintain good track records in managing routine fish diseases. Also, recent changes in CDFG policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting listed stocks through disease.

Release Strategies

Release strategies have the potential to affect the wild population through several ecological interactions (Nickelson 2003; Flagg et al. 2000). Operational release strategies that reduce interactions of juvenile hatchery fish with wild fish include consideration of the age of releases, release size, acclimation and volitional releases, and selection of release locations.

Coho Salmon

In the BO for Permit 1067 (NMFS 2001c), the preferred release strategy is noted to be the release of smolts, with a second preference for the release of fingerling. A mortality of 90 percent for fingerling before they reach the yearling stage is commonly assumed for wild populations. If sufficient numbers of coho salmon are produced to allow for release of both smolts and fingerling, then a tagging regime will be implemented that allows comparison between the two release strategies. The first fish release is anticipated in spring 2004. Release protocols for both fingerling and smolt releases will be developed.

The size of a juvenile fish has been shown to affect its ability to compete, escape predators, and survive the ocean phase of its life-history. Stocking with hatchery-reared juveniles of a similar size to naturally-spawned individuals may decrease the probability of competition and predation, and minimize selection pressures that may accompany a clear difference in size. Coho salmon fingerling and smolts will be reared to a size that mimics the size of natural fish of the same age to minimize the risk of predation and competition with natural fish upon release.

Given that it may be impossible to protect between-population diversity within the Russian River Basin (because population sizes are small), managers will seek to avoid erosion of this component of variation on a larger geographic scale. To do so, the highest possible degree of homing fidelity will be maintained for coho salmon released in the Russian River. Coho salmon released as smolts will be acclimated in net-pens at the release site for at least 30 days prior to their release. The net pens will be monitored daily during this period.

Releases of fish for supplementation purposes should occur only in locations where the habitat capacity exceeds the requirements of the local, naturally-spawning population. Release of coho salmon into restored rearing habitat where coho salmon have been extirpated or where abundance is low would minimize negative competitive interactions. To minimize competition between hatchery-reared and naturally-spawned fish, fingerling and smolt releases will occur where there are no known populations of wild fish. Releases will occur in five different streams, which will reduce the potential for attracting predators that might occur with a larger release group in a single location. Monitoring and evaluation over time can provide data to guide future release strategies as coho salmon abundance changes.

Table 5-82 organizes the potential range of release strategies into five categories and provides each a score of 3 for the coho program. Habitat conditions will be surveyed for multiple years prior to juvenile releases to determine appropriate release locations and densities. While the development of acclimation facilities to allow volitional release in these locations is preferred, the limited access to streams in the Lower Russian River watershed may greatly restrict the opportunity for such facilities.

Table 5-82 Release Strategies Evaluation Criteria and Scoring for Steelhead and Coho Salmon

Category Score	Evaluation Criteria Categories	Score
5	No hatchery releases.	Chinook "no production."
4	Volitional smolt releases into areas with known habitat carrying-capacity.	Steelhead isolated harvest (CVFF).
3	Direct smolt releases into areas with known habitat carrying-capacity.	Steelhead isolated harvest (DCFH). Coho supplementation, captive brood.
2	Volitional smolt releases into areas with unknown habitat carrying-capacity.	
1	Direct smolt releases into areas with unknown habitat carrying-capacity.	

<u>Steelhead</u>

It is generally assumed that hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling rearing within the system (Flagg and Nash 1999; Pascual et al. 1995). The steelhead isolated harvest program will release only smolts.

Juvenile trapping studies conducted at the Mirabel inflatable dam indicate wild steelhead smolts are predominantly in the age 2+ class, whereas hatchery steelhead are 1+ smolts that have recently been released from the hatchery (Chase et al. 2001). It would be beneficial to track the migration of hatchery steelhead smolts downstream from Mirabel dam to determine whether they continue directly to the mouth and enter the ocean as age 1+ fish, or whether they stay within the lower Russian River to rear for an additional year.

The size of a juvenile fish is an indicator of the habitat it is likely to inhabit. Age 0+ steelhead prefer shallow, quiet water a few feet from shore, whereas age 1+ steelhead are found in deeper, faster water towards the center of the stream (Flagg et al. 2000). Steelhead are typically 140 to 160 mm in length before they begin to smolt and migrate to the sea (Flagg et al. 2000).

Screw-trap studies conducted at the Mirabel inflatable dam during the 2000 sampling season used the measured fork length (FL) to classify the fish into 0+, 1+, and 2+ age classes. The weekly average fork length of 0+ steelhead increased from 43.7 mm during the first week of sampling (April 8) to 84.0 mm during the last week (June 24). Six of the eight steelhead observed in the age 1+ class were trapped in June, and they ranged in size between 120 and 136 mm. The age 2+ steelhead were trapped predominantly in late April and exhibited a size range of 142 to 238 mm, with an average length of 172 mm (Chase et al. 2001).

The release size for fish from the existing Russian River isolated harvest program is 5 fish per pound, which for steelhead equates to a typical length of 210 mm. While this is within the observed size range of wild steelhead smolts in the 2+ age class, it is somewhat larger than the average size for the 2+ smolts. The proposed program will classify fish as yearling smolts when they approach 4 to 5 fish per pound. Although the hatchery steelhead are released as 1+ fish, they are in the same size range as wild steelhead smolts in the 2+ age class. To minimize the risk of ecological interactions from the isolated harvest production, the program employs release strategies that increase the spatial and temporal separation between hatchery and wild fish. The hatchery steelhead are reared to the same approximate size as wild steelhead smolts and released in the spring to mimic the natural fish emigration strategy and encourage rapid downstream migration to the estuary, thereby minimizing the risk of ecological interaction with listed fish. Additionally, releases are coordinated with lunar cycles, because this is believed to benefit from surges in thyroxine that occur in the fish on a monthly basis. To minimize potential effects related to predation, hatchery fish generally are not released immediately into spawning or rearing habitat. Releases take place only on Dry Creek and the East Fork Russian River, leaving additional rearing habitat in the basin unaffected. DCFH and CVFF each conduct releases in approximately 12 separate batches spread over a 3-month period, which is believed to reduce the potential for attracting predators. Straying is minimized through release of progeny at or very close to the rearing facility. Steelhead released at CVFF are imprinted first for a minimum of 30 days and releases are volitional. Table 5-82 organizes the potential range of release strategies into five categories and provides each a score of 3 for the DCFH and 4 for the CVFF.

Chinook Salmon

Because no releases of Chinook salmon would occur, there is no risk for the Chinook salmon “no production” program.

Duration in Hatchery Captivity

The duration of hatchery captivity has the potential to affect the wild population primarily through the mechanism of artificial selection. Simply stated, with a longer period of duration, more life-history stages may be subjected to artificial selection, and more traits may become susceptible to the effects of artificial selection.

Table 5-83 organizes the anticipated range of hatchery captivity into five categories and provides a score of 3 for the risk level for a steelhead isolated harvest program and a coho supplementation program. Captive broodstock programs, which derive spawners from hatchery-reared individuals collected as juveniles, have a greater risk of accumulation of artificially selected phenotypes than standard supplementation programs, which derive broodstock from naturally-spawned adult returns. Therefore, the score for the captive broodstock program is 2. Without hatchery captivity in any life-history stage, there is no risk for the Chinook salmon "no production" program (Table 5-83).

Table 5-83 Duration in Hatchery Captivity Evaluation Criteria and Scoring by Program

Category Score	Evaluation Criteria Categories	Score by Program Alternative
5	No hatchery captivity.	Chinook "no production."
4	Hatchery captivity through fry life-stage.	
3	Hatchery captivity through smolt life-stage.	Steelhead isolated harvest. Coho supplementation.
2	Hatchery captivity through adult life-stage.	Coho captive brood.
1	Hatchery captivity for repeated generations.	

Harvest Management

Harvest management has the potential to affect the wild population primarily through the mechanism of unintended harvest bycatch of the non-target population. To reduce the potential for deleterious effects, it is essential to monitor the effects of harvest on listed populations. Budget limitations have precluded the ability of CDFG to conduct harvest surveys in recent years, but funding may soon be available for such activities (R. Gunter, CDFG, pers. comm. 2002).

The isolated harvest program allows a fishery within the basin for hatchery-reared steelhead. Harvest of coho salmon is prohibited within the Russian River basin. While this strategy minimizes direct fishing mortality of coho salmon, indirect effects such as hooking mortality and harassment may still occur. There are no current estimates for incidental harvest levels of coho salmon within the Russian River. Table 5-84 organizes the potential range of harvest management decisions into five categories and provides a score of relative risk level. Because harvest will be allowed on steelhead, the score is 2 for all three listed salmonid species.

Table 5-84 Harvest Management Evaluation Criteria and Scoring

Category Score	Evaluation Criteria Categories	Score
5	No harvest allowed within basin.	
4	Harvest allowed on one or more non-listed, distinguishable/marked population, with comprehensive surveys to assess harvest, angler effort, and bycatch effects to wild population.	
3	Harvest allowed on one or more non-listed, distinguishable/marked population, with moderate survey activity.	
2	Harvest allowed on one or more non-listed, distinguishable/marked population, with minimal survey activity.	Co, St, Ch
1	No limits on harvest.	

*Co = Coho salmon, St = Steelhead, Ch = Chinook Salmon

5.6.2 Benefits Assessment of Proposed Fish Facility Programs on Listed Species

5.6.2.1 Reduction in Short-Term Risk of Extinction

Hatchery supplementation programs have an egg-to-adult survival advantage that can help reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability generally pose the greatest short-term risks, but genetic risks such as inbreeding can also be important concerns, especially in populations that persist at small size for some time. Both a standard supplementation and captive broodstock coho program can help to reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity.

A main objective of the coho captive broodstock program for the Russian River is to prevent extirpation of Russian River coho salmon. The 1995 status review (NMFS 1995) found that the Central California Coast Coho ESU was in danger of extinction. A status review update for coho salmon for the Central California Coast ESU (NMFS 2001b) analyzed presence-absence data and population trend data between 1989 and 2000, and found lower abundances in the 1990s than in the mid-to-late 1980s. (The 1996 and 1997 year classes were strong; conclusions were based largely on data collected in those years.) The values of coho salmon replacement rates (CSR) were less than 1 for 126 of 229 observations, indicating a significantly ($p = 0.0045$) higher likelihood that abundance decreased rather than increased. The Central California Coast Coho ESU was determined to presently be in danger of extinction. Supplementation programs would reduce this risk of extinction.

All available data suggest that the Russian River coho salmon spawning aggregate is at risk from demographic stochasticity and the loss of genetic variation. If the Russian River coho salmon aggregate survives unaided until the factors contributing to its decline are mitigated, recovery would likely be hindered by the loss of genetic variation.

A status review update for the California Coastal Chinook ESU (Busby et al. 1999) found that coastal California streams support small, sporadically monitored populations of fall-run Chinook salmon, and that population trends are mixed. In general, trends tend to be more negative along the south coast (Eel, Mattole, and Russian rivers). Monitoring of index areas in the Mattole and Russian river basins indicates declining trends in abundance, except for increasing abundance at the CVFF from 1992 to 1998 (Busby et al. 1999). Previous CDFG estimates for Chinook salmon were 100 to 500 adults. However, recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Long-term trends are not available. Estimates of absolute population abundance are not available for most populations in this ESU.

The available data suggest that the Russian River Chinook salmon naturally-spawning aggregate may not necessarily be at risk from demographic stochasticity and the loss of genetic variation.

5.6.2.2 Increase in Speed of Recovery

Factors that speed recovery of depleted populations are important for several reasons, both biological and social. For example, rapid recovery: 1) minimizes the time a population spends at low abundances, and at high risk; and 2) minimizes the time over which the reduction of healthy populations produce a risk to economic and social effects. Supplementation programs can likely result in healthy, self-sustaining populations only if at least one of the following conditions are met: 1) factors responsible for the original decline are addressed concurrently with supplementation; or 2) supplementation helps to propel a population out of a stable but depressed state into a higher equilibrium abundance. Supplementation efforts within the Russian River watershed, combined with ongoing habitat restoration efforts, would speed recovery through increased population abundance for coho salmon.

The Chinook salmon “no production” alternative would eliminate potential risks associated with hatchery supplementation. If monitoring shows that population trends are declining or that genetic variation is limited, supplementation efforts within the Russian River watershed could speed recovery through increased population abundance for Chinook salmon (see Section 5.6.5).

5.6.2.3 Restoration of Ecosystem Processes

Coho supplementation and captive broodstock programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native coho salmon. Clearly, the link between the ocean and fresh water provided by salmon migration is necessary for proper functioning of the ecosystems to which they are native. Salmon act as a conduit for the movement of marine nutrients and are a necessary food source for many native species.

Salmon also play an important role with regard to gravel recruitment, which affects stream morphology and in turn affects the habitat of other native species. Construction of redds promotes gravel recruitment, and may change the dimensions and stability of a streambed or channel. For example, redd construction along the banks of a stream may widen the channel. A wider streambed may be less prone to erosion and scouring during flood events, and hence may provide a more stable environment for aquatic biota.

5.6.3 Summary of Effects and Benefits of Proposed Programs on Listed Species

Steelhead

The proposed (and current) DCFH and CVFF isolated harvest program reflects a commitment to minimize effects on listed fish populations. Procedures for waste treatment demonstrate continuous compliance with regulated discharge standards for water quality. Broodstock protocols regarding source, spawning numbers, and mating procedures follow recommended procedures to minimize genetic effects within the hatchery population. The program's release strategies take practical measures to isolate the hatchery population from the wild population as a means of minimizing genetic interaction as well as ecological effects from predation and competition. The facilities maintain good track records in their ability to manage routine fish diseases, and recent changes in policy regarding importation of stocks have resulted in a condition with minimal likelihood of affecting listed stocks through disease. Rearing is conducted at moderate densities, and several NATURES techniques are incorporated in efforts to minimize domestication. Harvest management policies have implemented mass marking of all steelhead releases and a selective harvest of hatchery fish as a practical approach to minimizing harvest effects on wild populations.

In general, there is a low risk of adverse effects to listed populations. However, there is a low risk for some potential effects to occur. For example, hatchery fish may prey on listed natural fish because they are released at a larger size, and there may be more fishing pressure on natural fish than would have occurred if hatchery fish were not being released. Also, because the numbers of wild steelhead may be below the viable population threshold, the lack of a hatchery supplementation program to increase abundance of the wild population may in fact contribute to increased potential for inbreeding depression and loss of within-population diversity in the wild population.

Key benefits of the isolated harvest program include contributions toward mitigation requirements, and contributions to the steelhead harvest fishery.

Coho Salmon

Fish production for the purpose of supplementation differs from traditional production or mitigation by preserving demographic, genetic, and ecological characteristics of natural populations (Hard et al. 1992). Unfortunately, most literature dealing with salmon focuses on the effects of production or mitigation hatcheries on natural populations. The effects of supplementation-oriented programs would be quite different.

This analysis lacks the numerical data necessary to conclude that Russian River coho salmon stocks are not vulnerable to adverse effects that may result from the implementation of a standard supplementation or captive brood program. However, given the available presence/absence data for coho salmon, the Russian River spawning aggregate of the Central California Coast Coho ESU may be at risk of extinction. Overall, a properly maintained and managed supplementation program, such as the captive broodstock program implemented by CDFG in 2001, offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. If the preference of the fish management agencies is to preserve the genetic variability found within the Russian River spawning aggregate, conservation actions must proceed even in the face of scientific uncertainty. The results of the analysis suggest that a supplementation-oriented coho program would be invaluable in avoiding further genetic degradation of the Russian River aggregate in addition to providing a buffer against demographic risks of low adult returns.

Chinook Salmon

Given the available short-term data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk. Until additional data determine the status of naturally-spawning Russian River Chinook salmon, the "no production" alternative is the preferred program.

Table 5-85 provides a summary of the operational risk scores for the proposed coho salmon, steelhead, and Chinook salmon programs.

Table 5-85 Summary of Scores for Operational Risk Categories for Steelhead, Coho, and Chinook Programs

Operational Risk Category	Steelhead Isolated Harvest	Coho Supplementation	Coho Captive Brood	Chinook "no production"
Source of Broodstock	3	4	4	5
Numbers of Broodstock	4	3	3	5
Broodstock Sampling and Mating	3	3	3	5
Rearing Techniques	2	3	3	5
Release Strategies	4	4	4	5
Duration in Hatchery Captivity	3	3	2	5
Harvest Management	2	2	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

5.6.4 SYNTHESIS OF EFFECTS AND BENEFITS ACROSS LISTED SPECIES

Hatchery programs implemented for one species may have effects on other listed species. Introduction of hatchery fish has the potential to increase risks associated with inter-species predation and competition. Harvest management for one species may affect the wild populations of other species through unintended harvest bycatch of the non-target population.

The extent of competition/predation risk depends not only on specific hatchery practices, but also on the extent of habitat overlap for various life-history stages. Coho salmon, steelhead, and Chinook salmon have evolved to coexist with a certain amount of niche partitioning. For example, coho salmon spawn earlier in the year and larger young-of-the-year coho salmon can therefore out-compete steelhead young-of-the-year in their preferred pool habitat. Where steelhead and coho salmon juveniles coexist, steelhead are more likely to utilize run/riffle habitat. Steelhead, however, are more likely than coho salmon to successfully utilize a wider range of habitat types in the Russian River.

If abundances (naturally-spawned or hatchery-population components) are increased for one species, it may increase the inter-species risk of competition and predation. Some of the same hatchery practices that reduce the risk for intra-species interactions can help minimize this risk. By releasing hatchery fish at smolt size, the residence time for hatchery fish in the freshwater environment is minimized. It is recommended that any hatchery program release smolts in the same size range of wild smolts, and volitional release and acclimation facilities can help reduce straying. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, the risk of deleterious interactions can be reduced.

Differences in adult spawning times are likely to minimize potential competitive interactions for naturally-spawning salmonids. The greatest amount of habitat and temporal overlap is likely to occur for the juvenile rearing life-history stage. Because Chinook salmon in the Russian River have an ocean life-history stage, and because they generally utilize low-gradient tributaries and the upper mainstem, the opportunity for interaction is less extensive than for steelhead and coho salmon. (Chinook salmon spawning was observed well downstream of Dry Creek in November 2002, but this is not believed to be the main spawning area [S. White, SCWA, pers. comm. 2002b]). However, if a supplemented population of one species exceeds habitat capacity, it may affect naturally-spawned components of other species.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to all listed species increases.

Restoration programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native salmonid species. Restoration of ecosystem function is likely to benefit target and non-target species.

5.6.5 Future Alternative Fish Facility Programs

Most California hatcheries, including the DCFH and CVFF, were established for the purposes of mitigation and enhancement. With the listing of salmonid species under the ESA, efforts are underway in the Russian River to utilize the hatchery facilities to supplement naturally-spawning populations and aid in the recovery of listed species. A key question that remains to be answered is whether hatchery production can provide sustainability for naturally-spawning populations. As new information on the status of Russian River populations becomes available from the recovery planning, the DCFH and CVFF hatchery facilities may be able to contribute to recovery efforts in ways that differ from the proposed programs.

Benefit/risk analyses were developed to evaluate the relative risks and benefits of alternative hatchery programs (FishPro and ENTRIX, Inc. 2003). According to this analysis, it may be beneficial to implement future alternative hatchery programs if monitoring and evaluation indicate they are warranted.

Benefits and risks of hatchery alternatives are difficult to weigh, given the need for further studies. Furthermore, tradeoffs between benefits and risks could occur, such as:

- As divergence between hatchery and naturally-spawning populations are reduced, risks related to increased ecological interactions in the wild are increased.

- As broodstock numbers are increased, the risk of amplifying the genetic traits of the founding broodstock may be reduced, but the risk of domestication may increase.

- If diversity is increased through interbreeding in a hatchery environment, there could be an initial cost in terms of reduced fitness.

Within the Russian River, limited information on the status of salmonid populations makes it difficult to quantify potential benefits and risks. The M&E Plan identifies many of these data needs and outlines a process to collect data (FishPro and ENTRIX, Inc. 2003). Until these data are available, strategies can be implemented to reduce the potential risks associated with hatchery programs.

This section presents an analysis of a Chinook salmon supplementation program, based on an assumption that new data show the Russian River population of Chinook salmon to be below the viable population threshold.

In addition, this section presents an analysis for steelhead production referred to as integrated harvest. This alternative differs from the isolated harvest program evaluated earlier, primarily through the use of wild steelhead broodstock rather than using returning hatchery-reared fish. This program would create a significant reduction in the risk of genetic effects to the wild population. The implementation of this program assumes that the wild population of steelhead is stable or increasing, which again is dependent on the results of population studies that are likely to be completed through recovery planning efforts.

A future alternative program for coho salmon is not considered in this analysis, because it is believed that the proposed coho captive broodstock or supplementation programs are the only programs that will reduce the risk of extirpation of Russian River coho salmon, and it will likely be many years before the naturally-spawning coho population is self-sustaining.

5.6.5.1 Evaluation of Effects of Future Alternative Fish Facility Programs on Listed Fish Species

Sources of Broodstock

Based on present knowledge and as a matter of preference, it is assumed that both the steelhead integrated harvest alternative and the Chinook supplementation alternative will collect all broodstock from the supply of wild adult fish returning to the Russian River basin. However, the selection of a broodstock source ultimately will be dictated by availability. Within the constraints of availability, the following priorities are recommended:

1. Naturally-spawned broodstock collected in the most unbiased manner possible from the local target population(s), provided that collection of broodstock does not endanger the population.

2. Naturally-spawned adults from the nearest watershed, provided that collection of broodstock does not endanger the population. If several such sources are available, managers may wish to choose the location(s) that have a high probability of maintaining transfers, and that most closely match the environmental characteristics of the Russian River and tributaries. Further, when possible, managers may wish to consider using cryopreserved milt from local sources, if/when available, to fertilize the eggs of transferred females.

3. Hatchery-reared adults collected in the most unbiased manner possible from the local population. (This option is available immediately for the steelhead integrated harvest alternative. However, for the Chinook supplementation alternative, this option will be feasible only after 2 years of supplementation using wild Chinook salmon for broodstock, as the F1 hatchery-reared progeny of the broodstock begin to return to their release streams.)

To assess which of these three broodstock source priorities will least affect listed species, it is assumed that studies regarding both genetic structure and productivity will have been completed for the steelhead and Chinook salmon population(s) of the Russian River and surrounding basins. Based on this assumption, the following process will help determine which of the three broodstock sources will be used:

- Genetic analysis of Russian River population indicates acceptable levels of genetic variation, and population abundance of the Russian River population is above the viable population threshold:

  Steelhead: Supplementation using Priority 1 broodstock only at a level necessary to replace wild broodstock collected for harvest production. (This is the program assumed and described in this future alternative evaluation.)

  Chinook: Supplementation unnecessary.

- Genetic analysis of Russian River population indicates acceptable levels of genetic variation, and population abundance of the Russian River population is below the viable population threshold:

  Steelhead: Supplementation using Priority 1 broodstock to replace wild broodstock collected for harvest production as well as to increase naturally-spawning population.

  Chinook: Supplementation using Priority 1 broodstock. (This is the program assumed and described in this future alternative evaluation.)

- Genetic analysis of Russian River population indicates unacceptable levels of genetic variation:

  Steelhead and Chinook: Supplementation using Priority 2 broodstock.

- If there are no acceptable Priority 2 broodstock available, the steelhead and Chinook salmon supplementation program will utilize Priority 3 broodstock only until Priority 2 or Priority 1 broodstock become available.

Table 5-86 organizes the recommended priorities for broodstock source into five categories, and provides each category with a score of relative risk level. By utilizing local Russian River stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component is presumably identical to that of the wild population. Based on the experience gained from the Russian River coho salmon recovery program, it is assumed that determination of abundance and productivity of Russian River steelhead and Chinook salmon populations will be completed in the near future while wild adults remain available for broodstock collection. Should it be determined that supplementation is desirable, implementing a supplementation program using broodstock collected from the wild would be significantly more cost-effective than having to develop and maintain a captive broodstock. This effects analysis therefore assumes that program implementation will be initiated with the local broodstock source.

Numbers of Broodstock

The benefit/risk analyses evaluating Russian River fish facility operations (FishPro and ENTRIX, Inc. 2003) describes the science behind the development of escapement and broodstock goals based on probabilities associated with maintaining genetic variation and limiting demographic risks, both to the hatchery-reared and naturally-spawned components for any supplementation program population(s). The escapement and broodstock goals are formulated to provide for “genetic and life-history redundancy”; i.e., if a brood year is lost, either in the hatchery as a result of catastrophic failure or in the stream as a result of a random environmental event, the surviving component should maintain sufficient genetic and life-history variation to maintain the stock.

Table 5-86 Source of Broodstock Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score for Program Alternatives
5	Local broodstock source (target stock), collected in the most unbiased manner possible.	Steelhead integrated harvest, Chinook supplementation
4	Naturally-spawned broodstock source from the nearest watershed; or a combination of naturally-spawned and hatchery-reared broodstock from the local source.	
3	Hatchery-reared broodstock source from the local or nearest watershed; or naturally-spawned broodstock source from within the same ESU.	
2	Hatchery-reared broodstock source from within the same ESU; or naturally-spawned broodstock source from a different ESU.	
1	Hatchery-reared broodstock source from a different ESU.	

Steelhead Integrated Harvest Program

As described in FishPro and ENTRIX, Inc. (2002), it is estimated that 200 steelhead adults is the minimum number of broodstock required to maintain a 95 percent probability that alleles occurring at a frequency of 1 percent or greater will be retained for a period of 15 years, assuming an N_b/N ratio of 0.2. Allowing for a prespawning mortality of 5 percent increases the minimum broodstock number to 210. Based on the historic performance of DCFH and CVFF steelhead production, a minimum of 269 adults must be spawned to achieve the release goals of 500,000 smolts. Therefore, minimal risk of loss of genetic diversity exists in fish produced for the harvest program, due to the numbers of broodstock required for production.

For the integrated harvest program, a minimum of 269 wild broodstock will be collected from the Russian River basin each year. To assure that this practice does not affect the productivity of wild population, the program will release approximately 70,000 smolts each year (out of the 500,000 total smolt production) into Russian River tributaries that are the expected source of the wild steelhead broodstock. Since these smolts are the progeny of wild Russian River steelhead, presumably there is no genetic difference between the fish released and their wild cohorts. These fish will be marked as hatchery-reared fish and will be subject to harvest pressure, but any successful recruits returning to the release stream will be left in stream for natural spawning. Based on an estimated smolt-to-adult return (SAR) of 1.0 percent (per DCFH and CVFF records), and assuming a harvest rate of 15 percent, approximately 595 adult F1 steelhead are expected to spawn naturally in the release stream. Assuming a current productivity of 0.5 for the naturally-spawning population, these F1 adults will result in the return of approximately 298 F2 naturally-spawned and naturally-reared adult steelhead. With a wild broodstock collection goal of 269 adults, the supplementation portion of the integrated harvest program provides a slight cushion in the numbers of naturally-spawned fish produced to compensate for the annual number collected from the environment. Since this number once again exceeds the minimum number of broodstock necessary to maintain genetic diversity, minimal risk to the naturally-spawned population is caused by the number of fish used for broodstock.

Chinook Salmon Supplementation Program

FishPro and ENTRIX, Inc. (2002) describes that, assuming an N_b/N ratio of 0.2, a minimum in-stream escapement goal of 726 adults per year is recommended for the Chinook supplementation program. A subset of this goal is the ability to collect 242 naturally-spawned adults as broodstock for the hatchery component of the program, leaving at least 478 adults (comprised of both hatchery-reared and naturally-spawned individuals) remaining as broodstock for in-river spawning. These broodstock collection goals meet or exceed the minimum recommended numbers for maintaining genetic diversity in each population component, and thereby minimize any potential genetic effect to the listed population. However, current estimates of population performance—including an estimated productivity of 0.5 for the naturally-spawning population and an estimated SAR of 0.2 percent (assuming a slightly improved SAR over the estimated 0.15 percent experienced with the previous DCFH Chinook production program—indicate possible periodic difficulty in achieving the minimum escapement goal. Monitoring and assessment of population performance measures will be completed annually to assess whether Chinook supplementation release numbers should be adjusted upward to achieve the instream escapement goals.

Evaluation

It is assumed that implementation of the steelhead integrated harvest program and Chinook salmon supplementation will occur only after completion of relevant studies relating to abundance and population growth rate in the Russian River basin. Supplementation will be implemented only if it can be demonstrated that wild broodstock are available for collection in numbers greater than the minimum broodstock size, and that removal of these broodstock from the environment will not reduce the wild population to a level less than the minimum effective population size. Table 5-87 organizes the potential range broodstock availability into five categories, and provides a score of 5 for the relative risk level for both the steelhead integrated harvest program and the Chinook supplementation program.

Table 5-87 Numbers of Broodstock Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	Maintenance of N_b necessary to maintain genetic variation with a 95% probability, in both instream and hatchery components.	Steelhead isolated harvest, Chinook supplementation
4	Instream escapement > 50% N_b and hatchery broodstock > 75% $N_{b.}$	
3	Instream escapement < 50% N_b and hatchery broodstock > 50% $N_{b.}$	
2	Instream escapement < 50% N_b and hatchery broodstock < 50% $N_{b.}$	
1	Instream escapement < 50% $N_{b.}$	

Broodstock Sampling and Mating Protocols

The following broodstock sampling and mating protocols will be implemented as recommended by NOAA Fisheries (Hard et al. 1992):

- A primary goal of the sampling program should be to obtain a representative sample for use as broodstock while allowing a representative sample to remain in the wild.

- Sampled adults should represent the entire run with regard to size, age, and other measurable phenotypic characters that may have adaptive value.

- If the number of available natural spawners is large enough to permit a large sample to be taken, random sampling (sampling without regard to measurable characters) is likely to ensure that the natural population is represented adequately in the broodstock. If the number of natural spawners is too small to permit a large sample, however, systematic sampling on the basis of measurable characters (particularly run timing and size and age at maturity) may be required to achieve adequate representation.

- The mating design should be chosen to equalize as much as possible the contributions of parents to the next breeding generation. This procedure will maximize N_e (effective population) for a given number of breeders and minimize the effects of selection.

- If possible, parents should be mated at random with regard to phenotypic characters that may have adaptive value (e.g., age and size at maturity).

- Mating design may include matings of single pairs, matings of single females to overlapping pairs of males, or factorial designs involving crosses between all possible parents. A modified single-pair design is generally preferable to simple matings of single pairs because it reduces risk of loss due to infertile males. A factorial design, assuming that the realized variance in progeny number is small, increases the probability of unique genetic combinations in the progeny. However, a complete factorial design will generally be feasible only with very small populations, since the benefits rapidly decrease (and the logistical difficulties rapidly increase) with increasing numbers of adults.

- Gametes from different individuals should not be mixed prior to fertilization, since mixing would affect the contribution of some individuals if variability existed in the potency of milt.

- In very small populations, a fraction of the milt from each male should be cryopreserved to maintain a "sire bank." These gametes can provide additional male "breeders" in years when the number of available males is low. Moreover, such crosses between brood years can help to preserve long-term genetic variability if severe population bottlenecks have been frequent or persistent.

Broodstock sampling and mating protocols have the potential to affect the wild population, primarily through the mechanisms of loss of within-population diversity and outbreeding depression, as discussed in FishPro and ENTRIX, Inc. 2003. It is assumed that the status of the wild steelhead and Chinook salmon populations in the Russian River basin would allow for random mating, should either of the alternative programs be approved for implementation. However, it is unknown whether the Russian River supports distinct or isolated spawning aggregates having population sizes less than the recommended minimum broodstock number, and this condition may exacerbate the potential of sibling mating within the wild broodstock collected for spawning. For the proposed steelhead integrated harvest program and Chinook supplementation program, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population. Table 5-88 organizes the potential range of sampling and mating procedures into five categories, and provides a score of 3 for the risk level for an isolated harvest program.

Table 5-88 Broodstock Sampling and Mating Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	Large naturally-spawning component allowing random mating.	
4	Large broodstock with pedigree mating.	
3	Large broodstock with random mating; or medium broodstock with pedigree mating.	Steelhead integrated harvest, Chinook supplementation
2	Medium broodstock with random mating; or small broodstock with pedigree mating.	
1	Random mating precluded in naturally-spawning component (due to small population size and/or isolation).	

Rearing Techniques

Naturalized Rearing Environments

As described by FishPro and ENTRIX, Inc. (2002), the degree to which artificial selection might be expected to result in the divergence of phenotypes among hatchery-reared adults or juveniles is related to the difference in selective regimes between the hatchery and natural environment. The NATURES described by Maynard et al. (1996) attempts to decrease the potentially deleterious effects of artificial selection by minimizing selective differences between the two environments. The NATURES approach utilizes naturally-colored raceways and rearing ponds, natural substrates, rearing unit covers, subsurface feeding, and lower rearing densities (among other factors) in an effort to mimic natural conditions in the hatchery. While implementation of these methods may not increase survival per se, implementation of NATURES methods might be useful as a means of avoiding cryptic side effects of artificial selection.

The existing DCFH rearing facilities incorporate NATURES features by providing covers and shading for the outdoor rearing units. CVFF includes the NATURES feature of volitional release. Both facilities, however, were designed assuming higher densities than is commonly preferred by today's standards. With the bulk of production for the steelhead integrated harvest program aimed at providing harvest opportunity, it is assumed that continued use of existing rearing facilities and methods will provide adequate performance and survival for a successful program. For a Chinook salmon supplementation program, however, in which the fish are expected to adapt to the natural population, it is assumed that new facilities will be provided to allow low density rearing. Table 5-89 indicates a score of 2 for the steelhead integrated harvest alternative, and a score of 3 for the Chinook supplementation program.

Table 5-89 Rearing Techniques Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	
4	Low density rearing with multiple NATURES features.	
3	Low density rearing.	Chinook supplementation
2	High density rearing with NATURES features.	Steelhead integrated harvest
1	High density rearing.	

Fish Health

Potential effects relating to fish health for the future alternative programs are identical to those described in Section 5.6.1.3 for the proposed programs. It is assumed that adherence to fish health management guidelines would minimize risk of disease transfer from the hatchery to wild populations to an undetectable level. It is further assumed that implementation of either the steelhead integrated harvest program or the Chinook supplementation program would include an element in the monitoring and evaluation plan to measure the incidence of pathogens in supplementation release streams.

Release Strategies

Release strategies have the potential to affect the wild population through several ecological interactions. Operational release strategies include age of releases, release size, acclimation, and volitional releases and selection of release locations.

Steelhead Integrated Harvest Program

Release strategies recommended for the potential future integrated harvest program are nearly identical to those of the proposed isolated harvest program. As a consequence, the potential effects of the integrated program are very similar to those described in Section

5.6.1.3 for the isolated program. The potential effects are repeated here for convenience, with minor variations as relevant for the integrated harvest program.

It is generally assumed that hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling rearing within the system. The steelhead integrated harvest program will release only smolts.

Juvenile trapping studies conducted at Mirabel dam indicate wild steelhead smolts are predominantly in the 2+ age class, whereas hatchery steelhead are 1+ smolts that have recently been released from the hatchery (Chase et al. 2001, 2002, 2003). It has been recommended as part of the existing steelhead isolated harvest program to track the migration of hatchery steelhead smolts downstream from Mirabel dam to determine whether they continue directly to the mouth and enter the ocean as age 1+ fish, or whether they stay within the lower Russian River to rear for an additional year. Depending on the results of these efforts, it may be desirable to consider increasing the release age of steelhead smolts for the proposed integrated harvest program. However, rearing the fish for an additional year would require a tremendous increase in the amount of space and flow at the DCFH and CVFF facilities.

The size of a juvenile fish is an indicator of the habitat it is likely to inhabit. Age 0+ steelhead prefer shallow quiet water a few feet from shore, whereas Age 1+ steelhead are found in deeper, faster water towards the center of the stream (Flagg et al. 2000). Steelhead are typically at least 140 to 160 mm in length before they begin to smolt and migrate to sea (Flagg et al. 2000).

Screw trap studies conducted at Mirabel inflatable dam during the 2000 sampling season used the measured fork length to classify the fish into 0+, 1+, and 2+ age classes. The weekly average fork length of 0+ steelhead increased from 43.7 mm during the first week of sampling (April 8) to 84.0 mm during the last week (June 24). Six of the eight steelhead observed in the 1+ age class were trapped in June, and ranged in size from 120 to 136 mm. The Age 2+ steelhead were trapped predominantly in late April and exhibited a size range of 142 to 238 mm, with an average length of 172 mm (Chase et al. 2001).

The release size for the existing Russian River isolated harvest program is five fish per pound, which for steelhead equates to a typical length of 210 mm. While this is within the observed size range of wild steelhead smolts in the 2+ age class, it is somewhat larger than the average size for the 2+ smolts. The future integrated harvest program will classify fish as yearling smolts when they approach four to five fish per pound. Although the hatchery steelhead are released as 1+ fish, they are in the same size range as wild steelhead smolts in the 2+ age class.

Release locations for the integrated harvest program are intended to increase the spatial and temporal separation between the harvest component and broodstock supplementation component. Releases of the harvest component will take place only on Dry Creek and the East Fork Russian River, leaving the remainder of rearing habitat in the basin unaffected. Straying is minimized through release of progeny at or very close to the rearing facility.

Steelhead releases at CVFF will be imprinted first for a minimum of 30 days and releases are volitional. Release locations for the broodstock supplementation component will occur in the same stream(s) from which broodstock are collected. Table 5-90 organizes the potential range of release strategies into five categories, and provides each a score of 3 for the DCFH harvest and supplementation components and 4 for the CVFF harvest component.

Table 5-90 Release Strategies Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery releases.	
4	Volitional smolt releases into areas with known habitat carrying capacity.	Steelhead integrated harvest (CVFF)
3	Direct smolt releases into areas with known habitat carrying capacity.	Steelhead integrated harvest (DCFH), Chinook supplementation
2	Volitional smolt releases into areas with unknown habitat carrying capacity.	
1	Direct smolt releases into areas with unknown habitat carrying capacity.	

Chinook Supplementation Program

Different life-stages of fish may experience differing levels of resource limitation, depending on the time and duration of resource utilization. Even in a supplementation program with intended interaction when the adults return, there may be a benefit to fish release practices that minimize temporal overlap in the hatchery-reared and naturally-spawned components, suggesting a preference for smolt releases over fingerling releases. Hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling reared within the system. It is assumed that the Chinook supplementation program will release 0+ smolts in the spring.

Screw trap studies conducted at Mirabel inflatable dam measured the fork length of fish that were trapped. Chinook salmon emigrate through the Wohler Pool at an average of 90 mm FL (range approximately 35 mm to 140 mm) (Chase et al. 2002). During the 2000 sampling season, the weekly average fork length of 0+ Chinook salmon increased from 81 mm during the first week of sampling (April 8) to 105 mm during the last week (June 24) (Chase et al. 2001). Chinook salmon averaged approximately 35 to 40 mm FL during the first few weeks of their life in 2002, then quickly grow to approximately 80 mm by mid-April. A similar size is recommended for the Chinook salmon supplementation releases as a means of mimicking the life-history characteristics of the wild population.

The release location for the Chinook supplementation program will occur only in locations where the habitat capacity exceeds the requirements of the local naturally-spawning population. This indicates the importance for resource managers to identify the area of habitat utilization for various life-stages. Release of Chinook salmon into restored rearing habitat where Chinook salmon have been extirpated or abundance is low, would minimize negative competitive interactions. Monitoring and evaluation over time can provide data to guide future release strategies as Chinook salmon abundance changes.

Table 5-90 organizes the potential range of release strategies into five categories and indicates a score of 3 for the Chinook supplementation program. It is assumed that habitat conditions will be surveyed for multiple years prior to juvenile releases to determine appropriate release locations and densities. While the development of acclimation facilities to allow volitional release in these locations would be preferential, the limited access to streams in the Russian River watershed may greatly restrict the opportunity for such facilities.

Duration in Hatchery Captivity

The duration of hatchery captivity has the potential to affect the wild population primarily through the mechanism of artificial selection. The rate and extent to which phenotypic, genetic and behavioral divergence may occur within the hatchery environment is largely dependent on selective pressure within the hatchery, and the number of generations the hatchery-reared stock has been isolated from the donor stock. Typically, divergence requires many generations.

Many sources of artificial selection that could occur in a hatchery can be avoided, such as assuring a representative sampling of all available broodstock. However, it is not possible to avoid all sources of artificial selection. For example (as discussed in FishPro and ENTRIX, Inc. 2003), culling eggs or juveniles exhibiting a high titer for bacterial kidney disease may result in inadvertent selection against those individuals possessing a natural resistance to the disease. All things being equal, one would expect the number of diverged traits and the magnitude of divergence to increase with the duration of captivity. Table 5-91 organizes the anticipated range of hatchery captivity into five categories and provides both the steelhead integrated harvest alternative and the Chinook supplementation program with a score of 3, since both alternatives utilize wild broodstock and release the progeny as smolts.

Table 5-91 Duration in Hatchery Captivity Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No hatchery captivity.	
4	Hatchery captivity through fry life-stage.	
3	Hatchery captivity through smolt life-stage.	Steelhead integrated harvest, Chinook supplementation
2	Hatchery captivity through adult life-stage.	
1	Hatchery captivity for repeated generations.	

Harvest Management

Harvest management has the potential to affect the wild population primarily through the mechanism of unintended harvest bycatch of the non-target population. To reduce the potential for deleterious effects, it is essential to monitor the effects of harvest on listed populations.

It is proposed that the steelhead integrated harvest program allow a fishery within the basin for the hatchery-reared steelhead, even though these fish are the progeny of wild, listed steelhead. Harvest of coho and Chinook salmon is prohibited within the Russian River basin. All hatchery-reared fish will be mass-marked, and it is assumed that harvest surveys will provide a measure of both the direct take (of hatchery-reared steelhead) and indirect take (bycatch of all wild salmon and steelhead) for all listed species. The production goals for the supplementation component of the steelhead integrated harvest program should then be updated periodically to reflect the observed harvest rate as it pertains to the broodstock return goals. While this strategy minimizes direct fishing mortality of coho salmon, steelhead, and Chinook salmon, indirect effects such as hooking mortality and harassment may still occur. Table 5-92 organizes the potential range of harvest management decisions into five categories, and provides a score of 3 on the assumption that routine harvest surveys will be implemented prior to approval of the steelhead or Chinook salmon program alternatives.

Table 5-92 Harvest Management Evaluation Criteria and Scoring for Future Alternative Steelhead and Chinook Programs

Category Score	Evaluation Criteria Categories	Score
5	No harvest allowed within basin.	
4	Harvest allowed on one or more non-listed, distinguishable/marked population, with comprehensive surveys to asses harvest, angler effort, and bycatch effects to wild population.	
3	Harvest allowed on one or more non-listed, distinguishable/marked population, with moderate survey activity.	Steelhead integrated harvest, Chinook supplementation
2	Harvest allowed on one or more non-listed, distinguishable/marked population, with minimal survey activity.	
1	No limits on harvest.	

5.6.5.2 Benefits Assessment of Future Alternative Programs on Listed Species

Reduction in Short-Term Risk of Extinction

Hatchery supplementation programs have an egg-to-adult survival advantage that can help reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability generally pose the greatest short-term risks, but genetic risks such as inbreeding can also be important concerns, especially in populations that persist at small size for some time. The Chinook supplementation program can help reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity. (The steelhead integrated harvest program assumes that the productivity of the wild steelhead population is equal to or greater than 1 and therefore not at risk of extinction; the supplementation component provides replacement fish for collected broodstock, ensuring no decrease in the wild population due to this practice.)

A status review update for the California Coastal Chinook ESU (Busby et al. 1999) found that coastal California streams support small, sporadically-monitored populations of fall-run Chinook salmon, and that population trends are mixed. In general, trends tend to be more negative along the south coast (Eel, Mattole, and Russian rivers). Recent monitoring of index areas in the Mattole and Russian river basins indicates declining trends in abundance, except for increasing abundance at the CVFF from 1992 to 1998 (Busby et al. 1999). Previous CDFG estimates for Chinook salmon were 100 to 500 adults, but recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Long-term trends are not currently available. However, it is assumed the Chinook supplementation alternative will not be implemented until long-term trends in abundance and the level of genetic variation in the naturally-spawning component of the population indicate that such a program would be beneficial.

Increase in Speed of Recovery

The Chinook supplementation program, combined with ongoing habitat restoration efforts, would speed recovery through increased population abundance for Chinook salmon.

Restoration of Ecosystem Processes

The Chinook supplementation alternative could contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native Chinook salmon. Clearly, the link between the ocean and fresh water provided by salmon migration is necessary for proper functioning of the ecosystems to which they are native. Salmon act as a conduit for the movement of marine nutrients and are a necessary food source for many native species.

5.6.5.3 Summary of Effects and Benefits of Future Programs

Steelhead Integrated Harvest

The steelhead integrated harvest program assumes that population abundance and growth rate studies for wild Russian River steelhead have been completed as part of the recovery planning efforts, and that the results of these studies indicate a population level greater than the viable population threshold and a stable or increasing trend in population. The main objective of changing from an isolated to an integrated harvest program is to minimize the genetic divergence between the hatchery-reared and naturally-spawning steelhead populations, while maintaining a smolt release program to support a recreational fishery and satisfy mitigation agreements. Production guidelines presented recommended measures to minimize potential genetic and ecological risks relating to broodstock collection and mating protocols, rearing and release methods, and harvest management.

Chinook Supplementation

The Chinook supplementation program assumes that population abundance and growth rate studies for Russian River Chinook salmon have been completed as part of the recovery planning efforts, and that the results of these studies indicate a population level less than the viable population threshold and a decreasing trend in population. Assuming further that, according to genetic studies, Russian River Chinook salmon are representative of the California Coastal Chinook ESU, a supplementation-oriented Chinook salmon program would be invaluable as a means of avoiding further genetic degradation of the Russian River aggregate in addition to providing a buffer against demographic risks of low adult returns. Production guidelines presented provide recommended measures to minimize potential genetic and ecological risks relating to broodstock collection and mating protocols, rearing methods, and release strategies.

Table 5-93 provides the operational risk scores for the proposed future steelhead integrated harvest and the Chinook supplementation programs.

Table 5-93 Summary of Scores for Operational Risk Categories for Future Alternative Steelhead and Chinook Programs

Operational Risk Category	Steelhead Integrated Harvest	Chinook Supplementation
Source of Broodstock	5	5
Numbers of Broodstock	5	5
Broodstock Sampling and Mating	3	3
Rearing Techniques	3	2
Release Strategies	3	3
Duration in Hatchery Captivity	3	3
Harvest Management	3	3

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

5.6.6 Summary of Effects and Benefits of Proposed and Future Programs

The DCFH and CVFF were established with legal obligations for mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. NOAA Fisheries has noted that hatchery production of Pacific salmon may be consistent with the purposes of the ESA in two situations: 1) when the hatchery production facilitates the recovery of a listed species; or 2) when the enhancement of unlisted populations does not impede the recovery of a listed species or compromise the viability or distinctiveness of an unlisted species (Hard et al. 1992). A conservation hatchery program is being considered to examine the role such a program may provide in reducing effects to listed species and to aid in their recovery.

Steelhead

Summary of Risks

Conclusions regarding the relative risk of the proposed steelhead isolated harvest program and the future alternative integrated harvest program operations are summarized in Table 5-94. By determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect (primarily inbreeding depression and loss of within-population diversity) can be minimized. There is some uncertainty about whether the Russian River system supports the minimum number of wild steelhead necessary to maintain genetic diversity. This suggests that the isolated harvest program has the potential to result in genetic effects to the remaining Russian River steelhead population.

Table 5-94 Summary of Scores for Operational Risk Categories for Proposed and Future Alternative Steelhead Programs

Operational Risk Category	Isolated Harvest	Integrated Harvest
Source of Broodstock	3	4-5
Numbers of Broodstock	4	4-5
Broodstock Sampling and Mating	3	2-3
Rearing Techniques	2	2
Release Strategies	4	3
Duration in Hatchery Captivity	3	3
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

The risk of loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. The total steelhead spawning aggregate in the Russian River appears to be greater than the minimum broodstock threshold level, but individual tributary populations may be too rare or isolated to allow random mating. Until adequate numbers of wild steelhead exist to assure that broodstock mining would not affect the broodstock threshold level of the remaining local stock, it is recommended that a mix of hatchery-reared and naturally-spawned broodstock be utilized for the integrated harvest program.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. It is proposed that, at a minimum, a supplementation program would operate under low-density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, the hatchery program would release smolts in the same size range of wild smolts, and volitional release and acclimation would help reduce straying. By releasing fish primarily into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced.

The risk of artificial selection in a hatchery increases with duration of captivity; more life-history stages may be subjected to artificial selection and more traits may become susceptible. Supplementation integrated harvest and isolated harvest programs that rear fish through the smolt lifestage have a higher risk.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the nontarget population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases.

<u>Summary of Benefits</u>

Potential benefits of steelhead hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes and cultural and social benefits (including harvest).

Increased egg-to-adult survival experienced with hatchery supplementation programs may reduce short-term extinction risks faced by natural populations. For very small populations, demographic and environmental variability pose the greatest short-term risks, but genetic risks such as inbreeding can also be important. The supplementation alternative can help reduce these risks, resulting in reduced extinction risk and conservation of genetic diversity.

Supplementation could help speed recovery through increased population abundance for steelhead. However, factors responsible for the original decline must be addressed.

By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity.

A properly maintained and managed harvest supplementation program offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. To preserve the genetic variability found within the Russian River spawning aggregate, the integrated harvest supplementation program may be the most appropriate, even in the face of scientific uncertainty.

Coho Salmon

<u>Summary of Risks</u>

Conclusions regarding the relative risks of the proposed coho production program are summarized in Table 5-95. By utilizing local stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component of the captive broodstock program is presumably identical to that of the wild population, reducing the risk of outbreeding depression and the loss of within-population or between-population diversity.

Table 5-95 Summary of Scores for Operational Risk Categories for Proposed Coho Program

Operational Risk Category	Standard Supplementation	Captive Brood
Source of Broodstock	4	4
Numbers of Broodstock	3	3
Broodstock Sampling and Mating	3	3
Rearing Techniques	3	3
Release Strategies	4	4
Duration in Hatchery Captivity	3	2
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

An estimated minimum of 840 wild, instream spawners is needed to maintain genetic variation over a period of 15 years (the estimated time-frame to achieve objectives). Based on the extremely low incidence of observed presence of coho salmon adults in the Russian River in recent years, less than half this number may be spawning naturally. This suggests that the proposed coho program is important to the recovery of the species.

The current status of coho salmon in the basin suggests that spawning aggregates may be too rare and/or too isolated to allow random mating, and therefore a risk of inbreeding exists. For the supplementation and captive broodstock programs, protocols for broodstock sampling and mating could ensure that the maximum genetic variability will be incorporated into the hatchery component of the overall population.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. At a minimum, it is expected that coho supplementation and captive brood programs would operate under low-density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, it is recommended that any hatchery program release smolts in the same size range of wild smolts, and volitional release and acclimation can help reduce straying. It is recognized that the limited access to streams on private property in the Russian River watershed may greatly restrict the opportunity for acclimation/volitional release facilities. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced. Monitoring and evaluation over time can provide data to guide future release strategies as coho salmon abundance changes.

The risk of artificial selection in a hatchery increases with duration of captivity. Captive broodstock programs, which derive spawners from hatchery-reared individuals collected as juveniles, have a greater risk of accumulation of artificially-selected phenotypes than standard supplementation programs that derive broodstock from naturally-spawned adult returns.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases.

Summary of Benefits

Potential benefits of hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes, and cultural and social benefits.

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. All available data suggest that the Russian River coho salmon spawning aggregate is at risk from demographic stochasticity and the loss of genetic variation. If the coho salmon aggregate survives unaided until factors contributing to its decline are mitigated, recovery would likely be hindered by the loss of genetic variation.

Supplementation and captive broodstock programs can likely result in healthy, self-sustaining populations only if at least one of the following conditions are met: 1) factors responsible for the original decline are addressed concurrently; or 2) supplementation helps to propel a population out of a stable but depressed state into a higher equilibrium abundance. Supplementation would speed recovery of coho salmon.

Supplementation and captive broodstock programs may contribute to the restoration of a functional ecosystem within the Russian River by increasing the abundance of native coho salmon. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity (following delisting).

Overall, a properly maintained and managed supplementation program, such as the Russian River pilot captive broodstock program implemented by CDFG in 2001, offers the opportunity to address many of the uncertainties surrounding the role of hatcheries in conservation. The results of this analysis suggest that a supplementation-oriented coho program will be invaluable as a means to avoid further genetic degradation of the Russian River aggregate, in addition to providing a buffer against demographic risks of low adult returns.

Chinook Salmon

Summary of Risks

Conclusions regarding the relative risk of the future alternative supplementation program as compared to the proposed "no production" program are summarized in Table 5-96. By determining and utilizing the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect (primarily inbreeding depression and loss of within-population diversity) can be minimized. It appears that the Russian River system supports the minimum number of wild Chinook salmon necessary to maintain genetic diversity. This suggests that the "no production" alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population, since all other programs would divert wild Chinook salmon from the natural-spawning population to an extent proportional to the benefit derived by reducing the potential for divergence between the hatchery-reared and wild populations.

Table 5-96 Summary of Scores for Operational Risk Categories for Proposed and Future Alternative Chinook Salmon Programs

Operational Risk Category	No Production	Supplementation
Source of Broodstock	5	4-5
Numbers of Broodstock	5	4-5
Broodstock Sampling and Mating	5	3
Rearing Techniques	5	3
Release Strategies	5	3
Duration in Hatchery Captivity	5	3
Harvest Management	2	2

Notes: 1. A score of 5 presents the least risk to the wild population.
2. A score of 1 may result in unacceptable conditions under the ESA.

The risk of loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. It is unknown whether spawning aggregates in the Russian River are too isolated to allow random mating. For the proposed supplementation program, approved protocols for broodstock sampling and mating would be implemented to ensure that the maximum genetic variability would be incorporated in the hatchery component of the overall population.

By decreasing the selective gradient between the hatchery and instream environment, the risk of artificial selection may be minimized. It is proposed that, at a minimum, the supplementation program would operate under low density rearing conditions, and that NATURES features would be added as appropriate.

To reduce potential effects related to competition and predation, it is recommended that any hatchery program release smolts in the same size range of wild smolts, while volitional release and acclimation can help reduce straying. By releasing fish for supplementation purposes only into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population, competitive interactions can be reduced.

The risk of artificial selection in a hatchery increases with duration of captivity; more life-history stages may be subjected to artificial selection and more traits may become susceptible. Supplementation programs that rear fish through the smolt life-stage have a higher risk than the "no production" alternative.

Harvest management may affect the wild population primarily through unintended harvest bycatch of the non-target population. If harvest is allowed on one or more non-listed, distinguishable/marked populations (such as hatchery steelhead) with no harvest surveys, the risk to listed species increases under any alternative.

Summary of Benefits

Potential benefits of hatchery programs may include reduction in short-term risk of extinction, increase in speed of recovery, restoration of ecosystem processes, and cultural and social benefits.

By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Additional benefits associated with implementation of hatchery programs could include fulfillment of legal mandates (e.g., existing mitigation requirements), reducing uncertainties with regard to ecosystem conditions, public education, and increased harvest opportunity.

Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed. Recent data from video monitoring at the Mirabel Inflatable Dam indicate a current naturally-reproducing population in the Russian River in excess of 1,300 adults (Chase et al. 2001; 2002). Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk and indeed may be a self-sustaining population. Until additional data determine the status of naturally-spawning Russian River Chinook salmon, the "no production" alternative may be the preferred action.

5.6.7 Summary of Effects and Benefits

5.6.7.1 Proposed and Future Fish Production Programs

The DCFH and CVFF have been operated under established mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. Under the proposed project, a conservation hatchery program would be implemented for coho salmon to aid in their recovery. The isolated harvest program for steelhead would continue, with an option for a future integrated harvest program. Chinook salmon production would be halted, with an option for a future integrated supplementation program.

5.6.7.2 Coho Salmon

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. Given the low numbers of coho salmon, it is clear that the Russian River spawning aggregate is at risk of extinction. A properly maintained and managed supplementation program, as begun by CDFG's Russian River pilot captive broodstock program implemented in 2001, would be invaluable as a means to avoid further genetic degradation of the Russian River aggregate. It would also increase coho salmon populations in the Russian River and provide a buffer against demographic risks of low adult returns.

Potential risks to the Russian River coho salmon population associated with the proposed hatchery programs include reduction of genetic viability in coho salmon stock, competition with hatchery-produced coho or steelhead, and predation by hatchery steelhead. By using local coho salmon stocks as the source of broodstock and implementing a carefully crafted breeding program, the captive broodstock and supplementation programs can substantially reduce the risk of loss of genetic diversity. New rearing techniques, including low-density rearing conditions and the use of NATURES features would reduce artificial selection, improving the fitness of hatchery outplants. Potential competitive interactions among naturally-spawned coho salmon and coho from the captive breeding program would be reduced by releasing coho into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population.

5.6.7.3 Steelhead

The proposed steelhead isolated harvest program would contribute toward mitigation requirements and sustain a recreational steelhead fishery while minimizing effects on listed fish populations. As with the coho salmon program, hatchery protocols would be implemented to minimize genetic and ecological risks to the naturally-spawning steelhead population. Appropriate broodstock sampling and mating protocols would be implemented. Programs that rear fish through the smolt life-stage have a higher risk of artificial selection than those that release smaller fish. As described for coho salmon, new rearing techniques would reduce the risk of artificial selection. To reduce possible effects related to potential competitive interactions or predation, the hatchery program would release steelhead smolts in the same size range as wild smolts, and volitional release and acclimation would help reduce straying.

A future alternative integrated harvest program, which would use wild steelhead broodstock rather than only hatchery-reared fish, would significantly reduce the risk of genetic effects to the naturally-spawning population. The integrated harvest program may be implemented if needed to protect genetic integrity of steelhead in the Russian River. Potential benefits may also include reduction in short-term risk of extinction and increase in speed of recovery. By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. However, factors responsible for the original decline must be addressed.

5.6.7.4 Chinook Salmon

This BA currently proposes a “no production” program. Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk, and indeed it may be a self-sustaining population. This suggests that the “no production” alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population.

A supplementation program could be implemented if population trends indicate that this action is needed to prevent the Russian River population of Chinook salmon from declining below the viable population threshold. Potential benefits of future supplementation programs include reduction in short-term risk of extinction, increase in speed of recovery, and restoration of ecosystem processes. By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed.

The loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. For the proposed future supplementation program, approved protocols for broodstock sampling and mating would be implemented. The future Chinook salmon program would incorporate new rearing techniques to reduce artificial selection, low-density rearing, and volitional-release programs to reduce competition and predation pressures on the local naturally-spawning population. Fish would be released into locations where the habitat capacity exceeds the requirements of the naturally-spawning population.

5.7 SUMMARY OF EFFECTS AND BENEFITS

5.7.1 FLOOD CONTROL OPERATIONS, WATER STORAGE, AND SUPPLY OPERATIONS

5.7.1.1 Operation of Coyote Valley and Warm Springs Dams

Channel Geomorphology

Flood control operations at dams can reduce the magnitude of peak-flood discharges in downstream areas. Adequate flows are periodically needed to maintain channel geomorphic conditions by mobilizing the streambed and transporting sediments. Such flows are necessary to flush fine sediments from the streambed and provide suitable spawning and rearing conditions for salmonids. However, if flood releases are of sufficient magnitude and frequency to regularly scour redds, spawning may be negatively affected. Ideally, there would be a balance between periodic mobilization of the streambed, transport of sediment and sediment deposition, and stability of spawning gravels.

Flood control operations are not likely to have a substantial effect on salmonids or their habitat downstream of Coyote Valley Dam. To minimize bank erosion, flood control operations are often timed so that reservoir outflows are an insignificant portion of the total streamflow at Hopland or Cloverdale. The flood regime on the Upper Reach Russian River, which can be influenced by operations at Coyote Valley Dam, would continue to be adequate to maintain channel geomorphic conditions. Steelhead and Chinook salmon redd scour would continue to occur more frequently in the Middle Reach Russian River than in the Upper Reach, but this is due to accretion from tributaries rather than flood control operations.

Flood control operations at Warm Springs Dam would not contribute significantly to prolonged flows above the threshold that initiates streambank instability and erosion in most years in Dry Creek. Flood control operations at Warm Springs Dam generally result in a reasonably good balance between streambed mobilization and spawning gravel stability for successful reproduction of steelhead and Chinook salmon. Coho salmon habitat may be scoured too frequently to provide for good reproduction in Dry Creek. Given the present geomorphology of Dry Creek, scour of coho salmon spawning gravels would likely occur even in the absence of flood control operations.

Flow Recessions

Releases from the dams would be ramped down during the receding limb of a flood hydrograph (winter season). Releases from the dams would also be ramped down or would cease during inspection and maintenance activities (summer season). Downstream habitat potentially may be subjected to flow recessions and dewatering, and juvenile salmonids may be stranded.

On the mainstem Russian River, ramping effects during flood control operations would be unlikely to strand fish. At the Forks, as in the past, there would usually be flow from the mainstem Russian River to attenuate ramping effects, and the backwater effect on the East Fork would attenuate stage changes. The stranding fish in Dry Creek would be unlikely given the ramping rates that would be used at Warm Springs Dam and the bypass flow capability of 25 cfs.

During annual inspections and repairs at Coyote Valley Dam under baseline conditions, there was a risk of stranding juvenile fish. Under the proposed project, annual inspections and repairs at Coyote Valley Dam would be scheduled between July 15 and October 15 to minimize the potential for stranding fry, the most vulnerable life-history stage. Low-flow ramping rates at Coyote Valley Dam would be reduced from 50 cfs to 25 cfs/hr, and bypass flows would be provided, creating substantially improved conditions for steelhead and Chinook salmon juveniles in the mainstem downstream of the Forks.

Under the proposed project, annual inspections and dam maintenance activities at Coyote Valley and Warm Springs dams would be unlikely to affect populations of listed fish species.

5.7.2 DIVERSION AND TRANSMISSION FACILITIES

Under baseline conditions, the potential to affect rearing fry and juveniles, and outmigrating smolts, was identified at the Mirabel and Wohler diversion facilities. The proposed project would minimize the potential for impingement of fry and juvenile salmonids during the diversion season by upgrading the fish screens at the diversion facilities to meet NOAA Fisheries criteria. Upgraded fish screens at the Wohler diversion would also reduce the potential for entrainment of juvenile fish into the Wohler infiltration ponds.

During flood flows, the levees at the Mirabel and Wohler infiltration ponds occasionally overtop and fish can be entrained. The levees at the Mirabel infiltration ponds would not overtop often, so the risk of entrapment would be low. Under baseline conditions, the risk at the Wohler ponds was higher. Under the proposed project, regrading the Wohler infiltration ponds and providing a continual connection to the river would reduce the potential to trap salmonids. Fish rescues would be provided in the Wohler and Mirabel infiltration ponds as needed. Although a few fish may be entrained in the Mirabel or Wohler ponds, the risk to the population under the proposed project would be low, substantially improved over baseline conditions.

Recent studies by SCWA and NOAA Fisheries conducted at the inflatable dam under baseline conditions suggest that the dam may delay downstream passage of steelhead smolts. These studies also suggest that Chinook salmon migration is not negatively affected currently. Creating a notch in the crest of the dam during the smolt outmigration period would improve smolt passage. Furthermore, integration of the intake structure and upstream end of the fish ladder would result in more effective use of river flows to create sweeping velocities and enhance downstream passage. These modifications would likely to benefit young coho salmon, steelhead, and Chinook salmon that encounter the diversion during downstream migration.

Inflation of the inflatable dam has the potential to cause flow recessions that strand fish. Deflation of the dam results in upstream stage changes and dewatered habitat that has a low risk of stranding juvenile fish. The risk to juvenile salmonids would continue to be highest during inflation of the dam, when river flows would be lower, and young fish might be stranded in riffles downstream of the dam. However, dam inflation and deflation occurs infrequently (on average, flow recessions would occur about three times per year).

The inflatable dam would continue to change habitat in the Wohler Pool from a combination of run/riffle/pool habitat to primarily pool habitat. This might reduce food transport during the early summer months when steelhead need it most to support increased metabolism. Summer water temperatures would be increased only slightly above natural warming through Wohler Pool, and high summer water temperatures would likely limit summer rearing habitat in this part of the mainstem. Pool habitat that would favor warmwater predator communities would be created above the inflatable dam. However, data from fish sampling indicate that few of the predators sampled in this habitat are large enough to be a significant threat to juvenile salmonids. Although alterations in habitat occur in Wohler Pool, they would not be expected to have substantial effects on steelhead rearing or coho and Chinook salmon migration.

Operations and maintenance activities that use materials for water treatment or for facility maintenance would carry out under specified permits and restrictions and by trained personnel. Although a catastrophic spill (e.g., diesel fuel) could have significant effects over a local area, with spill prevention and control measures in place, the risk of such a scenario occurring be low.

Accidental spills from the water transmission system could introduce chlorinated water to streams in the watershed. SCWA has added dechlorination baskets and alerts to each of the valves that could spill, thereby eliminating the risk to salmonids.

5.7.3 Flow and Estuary Management

The current flow regime in both the Russian River and Dry Creek is determined by the requirements of D1610, water supply needs, and flood control operations. A flow/habitat study conducted jointly by USACE, SCWA, NOAA Fisheries, CDFG, and ENTRIX, Inc., determined that the current flow regime is higher than optimal in both streams for the summer rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX, Inc. 2003b).

SCWA developed the Flow Proposal based on the study findings and the desire to improve habitat conditions for these species, while continuing to meet water demands now and in the future at the water demand levels projected in the WSTSP. The focus of the Flow Proposal is to provide the best possible conditions during the summer months, when conditions would be most limiting to salmonids and when the effects of the project would be most pronounced. During the winter months, streamflows are largely the result of rainfall and runoff from unregulated tributaries, and project operations would be less important in determining streamflow. An additional objective is to allow the Estuary to remain closed during the summer months, thereby providing more stable habitat conditions and better rearing habitat for anadromous salmonids in this part of the watershed.

The effects of the Flow Proposal on salmonid habitat were evaluated relative to the salmonid habitat conditions that would occur under D1610 for *all* and *dry* water supply conditions and for current and buildout water supply demands. The daily flow, temperature and DO levels that would occur under both flow management scenarios were scored based on the criteria presented in Appendix C. The frequency of scores for the different scenarios were then tabulated for the comparison. The comparison focused mainly on the summer months (June through October) when project operations would have the greatest effect on habitat. The conditions during the other times of year were evaluated as well, but habitat conditions during the wetter months (November through May) would generally be much more similar between the Flow Proposal and D1610.

Under the Flow Proposal, flows in the upper and middle Russian River during June through October under *all* water supply conditions would decrease relative to D1610 by 45 to 80 cfs. Under *dry* water supply conditions, flows in the upper and middle Russian River would increase over D1610 by 5 to 30 cfs. At buildout under *all* water supply conditions, flows under the Flow Proposal would be 10 to 35 cfs higher than at current demand levels, but would remain lower than those that would occur under D1610. Under *dry* water supply conditions at buildout, the Flow Proposal would result in flows 10 to 40 cfs higher than D1610. This would occur because the Flow Proposal balances water supply from the two reservoirs differently than D1610, to maximize habitat values in the Russian River and Dry Creek.

From November through May the flows in the upper and middle Russian River would be similar between the Flow Proposal and D1610 under both demand levels and both water supply conditions.

In Dry Creek, the Flow Proposal would provide lower summer flows than D1610 under all water supply conditions and demand levels. Summer flows would be 25 to 30 cfs lower under current demand levels for all water supply conditions. At buildout, the Flow Proposal would result in flows that are 35 to 50 cfs lower than D1610 under *all* water supply conditions, and up to 100 cfs lower during some months in *dry* water supply conditions. Under *critically dry* water supply conditions, which occurred during only one year in the 90-year simulation period (2 percent of the summer months), flows under the Flow Proposal could be as high as 200 cfs, but this would still be lower than flows under D1610 for dry water supply conditions (which occur about 15 percent of the time). Flows in Dry Creek in February and March under the Flow Proposal would tend to be 20 to 80 cfs higher than under D1610 for all water supply conditions. Under dry water supply conditions, the two management scenarios have similar flows February and March, and in April and May flows under the Flow Proposal would be higher, 50 cfs as compared to 25 cfs under D1610.

These changes in flow would result in improved water temperatures in the upper Russian River during September and October under the Flow Proposal under *all* water supply conditions. This would occur because the coldwater pool in Lake Mendocino would not be depleted as quickly. This difference in water temperature would diminish with distance downstream, and would not be significant at Healdsburg. In *dry* water supply conditions (which occur much less frequently), the Flow Proposal would result in warmer water temperatures in the upper Russian River. Again the difference between the water management scenarios decreases with distance downstream of Lake Mendocino.

In Dry Creek, water temperatures at the upper end of the stream would generally be quite similar between the two water management scenarios. In lower Dry Creek under the Flow Proposal, water temperatures would be increased over those with D1610, but would remain in the range considered generally acceptable for summer rearing. Winter temperatures would be similar for the Flow Proposal and D1610 for both water supply conditions and demand levels.

In the following sections, the effects of these changes in flow and temperature on the habitat for each species were summarized. Dissolved oxygen values were highly suitable for all lifestages of all species throughout the Russian River and Dry Creek under both water management scenarios and water supply conditions. DO is not discussed further.

5.7.3.1 Coho Salmon

Coho salmon spawn and rear in tributary habitat, including Dry Creek, but do not spawn or rear in the mainstem. The Flow Proposal was designed to improve habitat for coho salmon, and might positively affect coho spawning, rearing, and migration habitat in Dry Creek and migration in the mainstem.

Russian River

In the mainstem, the Flow Proposal and D1610 would result in similar flows during the coho salmon upstream migration period (November through January). Flows are predicted to provide good to optimal migration conditions about 75 percent of the time for *all* water supply conditions and 65 percent of the time for *dry* water supply conditions, reflecting the lower flows during migration periods. This would occur for both current and buildout demand levels. Water temperatures would be suitable for migrating adult coho salmon 90 percent of the time.

Dry Creek

The most substantial benefit to coho salmon under the Flow Proposal would be an improvement in summer rearing conditions in Dry Creek. Summer rearing conditions would improve markedly with lower flows in the summer and fall (June through October), especially at buildout demand levels. The Flow Proposal would provide good to optimal rearing flows 90 to 95 percent of the time under *all* and *dry* water conditions. As summer habitat conditions are thought to be one of the primary limiting factors for coho populations, these improvements could help reduce the summer population bottleneck.

Higher flows in Dry Creek in January under the Flow Proposal would slightly improve upstream migration and spawning conditions near Warm Springs Dam. In lower Dry Creek at buildout demand, lower flows under the Flow Proposal would provide better spawning conditions than D1610.

Water temperatures in Dry Creek would be suitable for all life-history stages under both water management scenarios. The only exception would be that the median summer rearing temperatures in lower Dry Creek would be warmer than 15º C more frequently under the Flow Proposal, but would not reach highly stressful levels (warmer than 16º C).

5.7.3.2 Steelhead

The primary areas for steelhead spawning and rearing that might be affected by the Flow Proposal would be the Upper and Middle reaches of the mainstem and Dry Creek. The Upper, Middle, and Lower reaches of the mainstem and Dry Creek were evaluated for migration. Rearing could also occur in, and near, the Estuary.

Russian River

The primary benefit of the Flow Proposal in the Upper Russian River, which has the best mainstem habitat, would be to improve steelhead summer rearing habitat by reducing summer flows relative to D1610 and decreasing water temperatures during the late summer and early fall. Median flows in the Russian River under the Flow Proposal would be from 50 to 150 cfs lower than D1610 during the summer rearing months during *all* water supply conditions, but as much as 50 cfs higher during *dry* water supply conditions. From November through May, flows would be similar between the Flow Proposal and D1610.

Overall, flow-related summer rearing habitat for steelhead would be very good to optimal about 30 percent more often under the Flow Proposal than D1610 under *all* water supply conditions. Under the Flow Proposal, good flows would occur for steelhead rearing 85 percent of the time throughout the Russian River under both current and buildout demand levels. During *dry* water supply conditions, D1610 would provide lower flows during the summer months and thus, slightly better rearing flows than the Flow Proposal. However, both management scenarios would provide good rearing flows about 90 percent of the time throughout the mainstem under *dry* water supply conditions.

These flow changes during June through October under the Flow Proposal would result in a substantial reduction in water temperature in the Upper Russian River relative to D1610 during September and October, with a smaller reduction in August. The Flow Proposal is predicted to produce slightly warmer median water temperatures in the upper mainstem in June and July. Near Ukiah, suitable water temperatures are predicted to occur about 10 to 15 percent more often under the Flow Proposal than D1610 under *all* water supply conditions, while under *dry* water supply conditions, the reverse would be true. Water temperatures increase with distance downstream from Coyote Valley Dam, but temperatures remain below 21°C to Cloverdale. At Healdsburg, median temperatures exceed 22º C from June through September under both management scenarios and both water supply conditions. Such temperatures would likely be stressful to rearing steelhead.

Flows for spawning and incubation are similar for the Flow Proposal and D1610. These flows are generally too high, and are considered unfavorable for these lifestages at both demand levels and water supply conditions, although they are somewhat better under *dry* water supply conditions. Spawning and incubation would occur with the same success as they do currently. Predicted water temperatures under the Flow Proposal and D1610 do not differ significantly during the upstream migration, spawning, and incubation periods, regardless of water supply conditions or water demand. During these periods, temperatures under the Flow Proposal and D1610 are suitable throughout the mainstem, but potentially lethal temperatures may occur about 5 to 10 percent of the time from Healdsburg to the Hacienda Bridge (primarily in April and May). During *dry* water supply conditions, incubation temperatures are slightly less favorable above Cloverdale. The Flow Proposal and D1610 would provide similar temperature conditions for these steelhead lifestages.

Dry Creek

Reduced flows in Dry Creek would provide a substantial benefit to rearing steelhead during the summer months. Under D1610, flows would often be too high, especially at buildout demand level under *all* and *dry* water supply conditions. Under the Flow Proposal, flows would be moderated, thereby increasing the amount of suitable habitat for juvenile steelhead. Summer rearing scores increase from predominantly 1 and 2 under D1610 to predominantly 4 and 5 under the Flow Proposal for both current and buildout demand level. Under the Flow Proposal, good-to-optimal habitat conditions would be provided about 90 percent of the time. Under *dry* water supply conditions, flows increase for both the Flow Proposal and D1610 at buildout, but to a substantially larger extent under D1610, resulting in less favorable flow conditions for juvenile steelhead. Under the Flow Proposal during *dry* water supply conditions, flows would be good about two-thirds of the time and stressful for the remainder of the time, with conditions better at the downstream end of Dry Creek than immediately below Warm Springs Dam. With D1610, flows would be unsuitable most of the time under *dry* water supply conditions at buildout.

Flow conditions during the adult upstream migration period are similar under both water management scenarios. In the upper portion of Dry Creek, the Flow Proposal provides higher flow and better migration conditions under *all* water supply conditions, but D1610 provides better habitat under *dry* water supply conditions because it has fewer days with flows that would block migration.

Habitat conditions for steelhead spawning would be similar for D1610 and the flow proposal under *all* water supply conditions at current demand levels, with suitable spawning flows occurring 50 to 65 percent of the time. At buildout demand levels, the Flow Proposal would provide slightly worse spawning conditions. Flows would be less favorable about 4 percent more often. Under *dry* water supply conditions, the Flow Proposal would provide good spawning conditions about 85 percent of the time as opposed to 66 percent of the time under D1610 at both current and buildout demand levels.

In upper Dry Creek D1610 provides better incubation conditions because flow would be lower under *all* water supply conditions. Under *dry* water supply conditions, the Flow Proposal provides better overall conditions for incubation with many scores shifting from good to optimal due to higher flows in April and May. In lower Dry Creek the Flow Proposal and D1610 result in similar incubation conditions regardless of water supply condition or demand level.

For both the Flow Proposal and D1610, water temperatures in Dry Creek near the dam tend to be cool and constant because release water would be managed to meet temperature requirements of the DCFH. Although water temperatures increase in a downstream direction, they remain good to excellent for most lifestages. Both management scenarios provide similar temperature conditions for all lifestages.

Summer rearing is thought to be the lifestage most limiting to steelhead production in the Russian River watershed. During summer water temperatures are warm and flows in most of the tributary streams are low due to natural runoff patterns and some water diversions. The increase in summer rearing habitat in the upper and middle Russian River and Dry Creek that would be provided by the Flow Proposal may appreciably increase the likelihood of survival, by reducing oversummer mortality. Through greater survival, larger numbers of steelhead smolts will reach the ocean and may return as adults to spawn, contributing to recovery of steelhead.

5.7.3.3 Chinook Salmon

The Flow Proposal would affect Chinook salmon habitat in the mainstem Russian River downstream of Coyote Valley Dam and Dry Creek. Chinook salmon use the Lower Reach of the Russian River as a migration corridor. Spawning, incubation, and rearing habitat for Chinook salmon occurs in the Upper and Middle reaches of the mainstem and in Dry Creek. Chinook salmon are generally present in the river system from October through June, but are absent during the warm summer months when project operations have the largest effects on flow and water temperature. Flows in the mainstem Russian River would generally be influenced more by natural runoff than by project operations during the time when Chinook salmon would be present in the river. The exception would be during the early upstream migration period, August through October.

Russian River

Under the Flow Proposal, migration conditions for adult Chinook salmon would be improved relative to D1610 because elimination of summertime artificial breaching of the sandbar at the mouth of the estuary would prevent adult Chinook salmon from entering the river in August and September, when flow and temperature conditions would likely be unsuitable. Adult Chinook would remain in the ocean until river flows increase. This would result in a large temperature benefit to these salmon during upstream migration and also make upstream passage easier at shallow riffles, reducing migration delays while in the river. This would be particularly true under *dry* water supply conditions. However, this might also expose these fish to greater predation by marine mammals and sport fishing while in the ocean.

Conditions for Chinook salmon spawning and incubation would be similar under the Flow Proposal and D1610 for each water supply condition and demand level. Flows during this period would generally be higher than optimal, due to runoff from unregulated tributaries. Either management scenario would provide good spawning conditions about 40 percent of the time and stressful spawning conditions about the same proportion of the time under *all* water supply conditions and poorer scores during *dry* water supply conditions.

Flows for incubation would be poor about 60 percent of the time under either scenario at both demand levels. Flows for incubation would be improved during *dry* water supply conditions, providing good to optimal habitat 55 percent of the time.

Flows during the Chinook rearing period (February through June) would also be similar between the Flow Proposal and D1610. These flows would be higher than optimal for young Chinook salmon due to natural runoff. Habitat conditions would have high velocities about 75 percent of the time under *all* water supply conditions. Habitat conditions would be improved in the later portion of the season over those in the early part of the season. Reduced flows in *dry* water supply conditions would improve habitat conditions relative to *all* water supply conditions. Good to optimal rearing habitat would occur about 40 percent of the time, while marginal conditions (scores ≤ 1) would occur about 15 to 30 percent of the time.

Water temperatures for juvenile rearing, incubation, and spawning would be similar under both water management scenarios. These temperatures would be good to optimal for these lifestages 75 to 90 percent of the time. Predicted temperatures for rearing would generally be favorable in the Upper Reach. Water temperatures would increase in a downstream direction, but even at the Hacienda Bridge they would generally be good when Chinook salmon are in the system. Suboptimal water temperatures for rearing and emigration would occur in the Lower Reach in June.

Water temperature conditions for adult migration would be improved under the Flow Proposal. By managing the Estuary as a closed system, migrating adults would not be exposed to higher water temperatures associated with low flows in August and September. In general, the frequency of poor and marginal water temperatures would decline from over 40 percent under D1610 to about 7 percent under the Flow Proposal.

Dry Creek

The Flow Proposal would provide slightly better rearing conditions for Chinook salmon in Dry Creek relative to D1610, under *all* water supply conditions, and would provide very good habitat conditions about 60 percent of the time. D1610 would result in corresponding conditions about 10 percent less frequently. Very good conditions would occur about twice as frequently under the Flow Proposal than D1610 under *dry* water supply conditions.

The Flow Proposal and D1610 would provide similar conditions for Chinook salmon upstream migration, spawning, and incubation. Good to optimal flows for upstream migration would occur 85 to 95 percent of the time under *all* water supply conditions. Under *dry* water supply conditions, flows would be slightly better for upstream migrants under D1610, but both management scenarios would provide good to optimal flows a large proportion of the time. For spawning, both the Flow Proposal and D1610 would provide very good conditions about 85 percent of the time under *all* water supply conditions and more than 90 percent of the time under *dry* water supply conditions. Similarly, good conditions would occur under both scenarios for Chinook incubation.

Temperatures would generally be highly suitable for Chinook salmon rearing throughout Dry Creek under both the Flow Proposal and D1610. In upper Dry Creek, both management scenarios would provide very good water temperatures (8 to 17°C) all of the time. In lower Dry Creek, some warmer temperatures (up to 20°C) would occur under both scenarios, with D1610 resulting in a slightly lower frequency of warmer temperatures. At buildout, temperatures would improve slightly in lower Dry Creek for D1610. About 5 percent more days received a score of 4. Scores remained the same under the Flow Proposal.

5.7.3.4 Low-Flow Estuary Management

The Low-Flow Estuary Management proposal would result in a more stable ecosystem that would improve summer rearing habitat over conditions under D1610. The proposed action would allow a freshwater-dominated system to develop, stabilize water quality, improve primary productivity and the invertebrate foodbase, and stabilize marsh and shoreline vegetation. The species most likely to benefit would be steelhead, although coho and Chinook salmon juveniles might also benefit. Because inflow to the Estuary would be managed so that the sandbar would generally close after peak downstream migration periods, downstream passage would not be substantially affected, although spring or early summer sandbar closures could occur in dry years. Reduced inflow to the lagoon might result in reduced dilution of nutrients or pollution, but would be not expected to affect salmonids.

By managing WSE at approximately 7 feet or less during the dry season, the probability of unauthorized breaching by local community members would be reduced, thereby reducing potential negative effects related to breaching.

5.7.3.5 Storm-Flow Estuary Management

Artificial breaching would still be required to manage storm flow in the spring or fall, and in some dry winters, to prevent flooding of adjacent property. Artificial breaching would occur at the onset of the rainy season and would be scheduled as closely as possible to the time when a natural breach might occur. Under baseline conditions, artificial breaching allowed early adult Chinook salmon to enter the river when river conditions could be unsuitable. Under the proposed project, the sandbar would be breached when river conditions are more suitable, which would also reduce the potential for incidental angling pressure or poaching in the River. Chinook would be exposed to predation and sport fishing in the ocean before entering the river.

Late-season breaching, which would occur after a late spring storm, might be of concern in dry years if, after the storm, river flow rapidly decreases to a low level. In this case, insufficient river flow might result in a long period of time passing before the lagoon would be freshened. Under the proposed management program, inflow to the lagoon would be managed so that it would freshen the lagoon early in the season and to maintain stable, suitable habitat conditions through the summer.

5.7.4 CHANNEL MAINTENANCE

5.7.4.1 Central Sonoma Watershed Project and Mark West Creek Watershed

Under the proposed project, channel maintenance activities would continue to be conducted on specific constructed flood control channels and natural waterways (see Tables 3-12 and 3-14) to maintain flood capacity.

The risk of direct effects to fish would continue to be low during these activities because they generally would occur during the summer, protocols would be implemented to minimize injury to fish or sedimentation to habitat, and fish rescues would be conducted, if necessary. Indirect effects to habitat would be more likely to occur than direct effects.

Sediment Removal in Constructed Flood Control Channels

Sediment removal activities may have negative, direct effects on a few individual juvenile coho salmon, steelhead, or Chinook salmon. Disturbance to the streambank would be kept to a minimum, unless significant sediment had accumulated along the banks. Effective sediment control practices would be used during instream work in wetted channels. Channels would be assessed by SCWA biologists before sediment removal activities are performed; in the rare instance that listed species would likely be present, a barrier would be established to exclude fish and, if necessary, rescue would be performed. To date, barriers and fish rescues have not been necessary (S. White, SCWA, pers. comm. 2003c).

The channels that would require the most sediment maintenance are the low-gradient channels in the Rohnert Park-Cotati area. Many of these streams have limited spawning or rearing habitat due to low summer flows, high summer water temperature, and heavy silt loads. Because sediment-laden, constructed flood control channels do not generally provide rearing habitat for coho salmon or steelhead, few, if any, fish would be present, so the risk of injury to fish would continue to be low. While some individual fish might be exposed to injury, but there would be a low risk to any of the populations of listed fish species as a whole.

However, sediment maintenance might occur in channels that are migration corridors to upstream spawning or rearing habitat. Sediment removal could result in the loss of a low-flow channel that develops within some of the flood control channels, which could impede upstream and downstream migration at low flows.

Vegetation Maintenance

Under baseline conditions, vegetation has been maintained at the original design maintenance level to maintain hydraulic capacity (flood control) and to reduce fire dangers. Under the proposed project, vegetation maintenance practices would be conducted at three levels: the original design maintenance level, and two additional levels that would allow riparian vegetation to develop, the intermediate or mature riparian vegetation maintenance levels. These two levels would result in increased canopy cover in some channels. Under the proposed project, hydraulic capacity assessments would be conducted to determine the level of flood capacity needed, and this information would be used to reevaluate the level of vegetation maintenance needed. Some streams that currently receive greater levels of vegetation clearing could potentially be managed at a level that would allows more vegetation to develop.

Because most flood control channels that require frequent or extensive maintenance do not provide good quality spawning and rearing habitat, only fish passage would be affected. The risk to the overall population of coho salmon, steelhead, and Chinook salmon would be relatively small, because, generally, few individuals would be using flood control channels.

Effects would be of greater significance for those flood control channels in tributaries that support rearing and/or spawning habitat in their upstream portions. Channels that may potentially support summer salmonid rearing habitat upstream of the maintained area, but may require the original design maintenance scenario, include Paulin, Piner, Santa Rosa, Brush, Copeland, Crane, Laguna de Santa Rosa, Rinconada, and Todd creeks. For segments of these nine channels, implementation of the original design maintenance practices may have localized effects on rearing and/or migration habitat.

Vegetation Maintenance in Natural Waterways

For the natural waterways where vegetation removal might occur, SCWA does not have routine or regularly-implemented maintenance obligations. SCWA would remove vegetation on these other natural waterways only where there are site-specific problems with flood capacity. Therefore, the length of vegetation removal would be limited to small projects, generally 300 to 600 feet long.

While individual projects may be small, the sum of several projects may have larger effects, especially if they occur in important salmonid spawning and rearing habitat such as some of the natural waterways in Mark West Creek and its tributaries. Therefore, removal of instream and streambank vegetation would be kept to a minimum in these streams (i.e., only where significant flood control hazards or threats to structures exist). Vegetation removal in streams with limited rearing habitat (for example, some natural waterways in the Rohnert Park area) would not be as likely to diminish salmonid habitat, and therefore could safely be more extensive. Proposed vegetation removal activities, therefore, have a relatively low risk of short-term or long-term indirect effects to salmonid habitat (particularly coho salmon and steelhead) in natural waterways.

Debris Removal

Large woody debris would not likely play a significant role in providing structure or habitat in flood control channels, given the limited tree resources and recruitment processes. Therefore, the SCWA practice of limiting large woody debris removal to situations when it poses a flood control hazard would likely not result in substantial reduction of cover or scour. Because large woody debris is currently scarce in the flood control channels, restoration actions that would promote the planting or growth of native trees or that install instream structures that provide some of the functions of large woody debris would improve habitat for rearing or spawning, or (in the case of constructed flood control channels) for migration.

Flood Control Reservoirs

Four flood control reservoirs would continue to act to passively reduce flooding in the Santa Rosa area during the rainy season. Three of these are onstream reservoirs with minimum streamflow bypasses. These three reservoirs would continue to act as barriers to upstream migration for anadromous coho salmon and steelhead. A diversion structure on Spring Creek would also impede upstream migration.

Maintenance activities in the reservoirs would not affect salmonids directly. While there would likely be an increase in water temperatures in Santa Rosa Creek when Spring Lake is drained, this effect would be unlikely to exceed thresholds that would affect salmonid survival because water would be released as early as possible in the spring.

Only a small drainage area is captured by the Brush Creek, Piner Reservoir, and Spring Creek diversion facilities (although water from 2.3 miles of Spring Creek are diverted), so peak floods probably would not be significantly altered and resulting downstream effects probably would not be significant. Matanzas Creek Reservoir generally fills and spills after mid-December, so channel maintenance flow events would likely pass to the natural downstream reach later in the year. Because most of Santa Rosa Creek downstream of Spring Lake has been altered for flood control, attenuation of peak flows would not negatively affect the geomorphology of the creek.

Sediment and large woody debris retention on Brush Creek, Piner Reservoir, and the diversion on Spring Creek are low because these facilities are small, so effects to downstream habitat would likely be minimal. The capacity of Matanzas Creek reservoir is larger, so retention of spawning gravel in the reservoir may affect downstream spawning habitat. However, spawning habitat would be limited by other issues related to the geomorphology of the channel rather than by a lack of spawning gravel. While some spawning gravel may be retained in the reservoir, the risk to the populations of listed fish species would continue to be low.

When predators from Spring Lake would be released during high-flow events, they would not introduce a new risk. The additional fish passing downstream may help to maintain the local population of predators. The risk of predation would not be increased, but may be sustained.

The most significant effect of the flood control reservoirs would be the potential entrapment of anadromous salmonids into Spring Lake. Because good-quality spawning and rearing habitat occurs upstream of the diversion, it would be expected that some individual coho salmon, or more likely, steelhead, may be trapped. However, there would not be a long overlap between juvenile salmonid migration periods and the time water spills to Spring Lake. Water flows to Spring Lake about one day per year, so the risk to the populations of coho salmon, steelhead and Chinook salmon would be low.

5.7.4.2 Warm Springs and Coyote Valley Dam Projects in Dry Creek and Russian River

SCWA and MCRRFCD would continue to maintain the bank stabilization works installed as part of the Warm Springs Dam and the Coyote Valley Dam projects in Dry Creek and the mainstem Russian River, respectively. Activities would be limited to maintenance of existing structures. Most of these sites are in stable condition and would not require work in the near future. Effects would generally be limited to small-scale effects related to sediment input to the creek and some small amount of vegetation removal. Use of effective BMPs would reduce the risk of short-term effects. Therefore, both the short-term, direct effects to fish and long-term habitat effects would be low.

5.7.4.3 Gravel Bar Grading and Vegetation Maintenance for Bank Stabilization in the Russian River

In the mainstem Russian River, gravel bar grading and vegetation maintenance would continue to be conducted by two different agencies, the MCRRFCD and SCWA, each in their respective counties, to control bank erosion. Sediment maintenance work would consist of grading gravel bars and creating overflow channels during the dry summer season.

Because the work would occur in dry channels and gravel bars, direct effects to fish, and also sedimentation to aquatic habitat, would likely be minimal or nonexistent. Gravel bar grading and vegetation maintenance could however, have long-term effects to salmonid habitat. Steelhead and Chinook salmon use the mainstem for spawning, rearing, and migration.

Under the proposed project, these activities would be more limited than those conducted historically. No more than four bars (four in Sonoma County and four in Mendocino County) would receive maintenance in any one year, and the length of any one site would not exceed 1,000 feet. Gravel bar grading and vegetation removal on bars would be scheduled in rotation over a course of 3 to 5 years, so that high-flow velocity refuge areas for salmonids (river meanders, pools, and vegetation) would develop and be maintained at some bars in any given year. Protocols would be implemented to preserve a buffer zone, grade the channel to minimize the risk of stranding fish during flow recessions, and preserve large woody debris. Although habitat would be altered at any one site in a year, the limitations under the proposed project are designed to ensure that sufficient, good-quality habitat would remain in the mainstem over time.

5.7.4.4 Emergency Bank Stabilization in Natural Waterways

Emergency sediment removal and bank stabilization work would occasionally be required in natural waterways after a large storm event, at landowner request and pursuant to approved contracts with the landowners.

Sediment removal and channel clearing activities have the potential to injure or kill fish. SCWA intends to reduce this risk by excluding fish from the work area with barriers or relocating them, if necessary.

Potential habitat alterations that may occur due to sediment removal in natural waterways include loss of shade canopy and cover, and loss of hydraulic and associated habitat diversity. The potential for habitat alterations due to sediment maintenance and bank stabilization in natural waterways to populations of coho salmon, steelhead, and Chinook salmon would continue to be small. This is due to the infrequent need for maintenance activities in natural waterways; the prescriptions for limiting the size of any one project to 1,000 feet; and the guidelines for incorporating bio-engineering, revegetation, and fish habitat elements into bank stabilization work.

5.7.4.5 Gravel Bar Grading in the Mirabel/Wohler Area

SCWA would continue to augment infiltration capacity for its water distribution system in the Mirabel and Wohler area by periodically grading gravel bars in the river in the area of diversion to increase infiltration in the river.

There would be no risk of direct injury to migrating juvenile salmonids during this activity at the Wohler, Bridge, and McMurray bars (upstream of the inflatable dam). The potential to injure juvenile steelhead at Mirabel would be slightly greater because steelhead may be trapped in the Mirabel Bar. Fish rescues would reduce the risk to a low level.

The potential to alter habitat with sediment input from instream activities would be addressed through use of BMPs. When gravel bars are graded, streambed sediments would be disturbed. During the first rainstorm, loose sediments might be mobilized, which could result in short-term increases in turbidity. Because these gravel bars are located in the lower river, sediments would probably not be deposited in primary spawning or rearing habitat. The overall risk for injury and habitat degradation would be low.

5.7.4.6 NPDES Permit Activities

Overall, the permittees have determined that the NPDES permit plans and associated activities have been effective. Chemical and biological monitoring results since 1998 indicate that no consistent trends or specific water quality constituents of concern have been identified (City of Santa Rosa, Sonoma County Water Agency, County of Sonoma, 1998, 1999, 2000). Bioassay results indicate very low toxicity of stormwater from sampled runoff events. Indirect indicators, including number of inspection and enforcement actions; amount of educational materials distributed; and amounts of pollutants removed through maintenance, spill response, and implementation of BMPs, indicate that the SWMP has been successful to date. NPDES permit plan activities would have a beneficial effect on listed species and their critical habitat.

5.7.5 Restoration and Conservation Actions

SCWA has implemented, funded, or planned projects designed to benefit listed species and their habitat in the Russian River watershed. These efforts include restoration projects (riparian and aquatic habitat protection, restoration and enhancement, fish passage); watershed management; support for state and federal recovery planning for coho salmon; restoration of the Riverfront Park property; and water conservation and reuse.

Collectively, most of these projects would have a substantial beneficial effect on the habitat of the listed fish species. Some types of restoration and conservation actions are likely to affect individual fish during construction activities, but there would continue to be no risk to populations of listed species as a whole. However, the lakes in the Riverfront Park property have the potential to entrap salmonids when floodwaters recede.

5.7.5.1 Funding and Priorities

SCWA commits substantial funds, staff, and equipment to restoration projects. Additionally, in-kind contributions of staff and equipment have been committed to restoration projects. Additional grant money has been, and would continue to be, pursued.

To maximize the effectiveness of the dollars invested, SCWA would continue to develop project priorities on a basin-wide level, and in cooperation with CDFG and other agencies and private interests in the watershed. SCWA would continue work to implement priorities and recommendations formally outlined by CDFG. Partnerships with other stakeholders in the watershed have been instrumental to the success of SCWA restoration projects and programs. SCWA would expand the indirect beneficial effects of restoration projects by taking advantage of opportunities for public education associated with the restoration projects.

5.7.5.2 Restoration Actions and Fish Passage Projects

Typically, larger projects provide more biological benefits than smaller projects. Conservation and restoration actions were evaluated quantitatively by assessing their *biological benefit*. The biological benefit score was based on the project size (length of stream affected), the time frame for expected benefits, habitat elements affected and their relative importance to listed fish species, stream inventory and/or population data, the cost vs. benefits of the project, and the educational value of the project.

Actions that are part of the proposed project include restoration on 16 different streams, affecting more than 50 miles of streams. Steelhead are the most abundant species in many of these areas, but as coho salmon populations are recovered, use of these streams by these species would likely increase. All projects listed would likely improve habitat for spawning, rearing, and migration of listed salmonids. BMPs to minimize negative effects are generally outlined during the permitting process.

The primary benefit of fish passage projects would be the additional spawning and rearing habitat that would become available to anadromous salmonids. The Mumford Dam modification project provides unrestricted access to approximately 45 miles of spawning and rearing habitat in the mainstem Russian River upstream of the Forks. This benefits steelhead and Chinook salmon and possibly coho salmon. This project also improves approximately 600 feet of habitat directly downstream of Mumford Dam. The improvements in Santa Rosa Creek in the Hood Mountain region improve access to approximately 10 miles of upstream habitat, which benefits coho salmon and steelhead.

SCWA is restoring property that was previously used for gravel mining to a public park. The lakes in the Riverfront Park area have the potential to entrap salmonids when floodwaters recede. Salmonids have a risk of being entrained, as one of these events occurs approximately every 1 to 2 years. The park property is located in the Lower Russian River, and adult and juvenile salmonids of all three listed fish species may be affected.

5.7.5.3 Water Conservation and Reuse

Water reuse and conservation are expected to reduce peak water demand approximately 3 to 5 percent. This would typically occur during the dry season in mid-summer. Water conservation is expected to help meet future, growing water demands, and may help to reduce the amount of water diverted from streams tributary to the Russian River.

5.7.5.4 Watershed Management Projects

Scientific research efforts, information dissemination, and regional coordination of management efforts are important components of the restoration and conservation of listed species and their habitat. Data on population trends and habitat use will help focus conservation actions where they will have the greatest effect. Genetic data are critical to decisions regarding artificial propagation, as well as providing insights to the long-term viability of existing populations. By sharing information and coordinating restoration actions with other groups, limited resources are focused so that the maximum number of beneficial effects can be realized.

5.7.6 Proposed and Future Fish Production Programs

The DCFH and CVFF have been operated under established mitigation and enhancement goals for coho salmon, steelhead, and Chinook salmon. Under the proposed project, a conservation hatchery program would be implemented for coho salmon to aid in their recovery. The isolated harvest program for steelhead would continue, with an option for a future integrated harvest program. Chinook salmon production would be halted, with an option for a future integrated supplementation program.

5.7.6.1 Coho Salmon

The main objective of the captive broodstock and supplementation programs for the Russian River is to prevent extirpation of Russian River coho salmon. Given the low numbers of coho salmon, it is clear that the Russian River spawning aggregate is at risk of extinction. A properly maintained and managed supplementation program, as begun by CDFG's Russian River pilot captive broodstock program implemented in 2001, would be invaluable as a means to avoid further genetic degradation of the Russian River aggregate. It would also increase coho salmon populations in the Russian River and provide a buffer against demographic risks of low adult returns.

Potential risks to the Russian River coho salmon population associated with the proposed hatchery programs include reduction of genetic viability in coho salmon stock, competition with hatchery-produced coho salmon or steelhead, and predation by hatchery steelhead. By using local coho salmon stocks as the source of broodstock and implementing a carefully crafted breeding program, the captive broodstock and supplementation programs can substantially reduce the risk of loss of genetic diversity. New rearing techniques, including low-density rearing conditions and the use of NATURES features, would reduce artificial selection, improving the fitness of hatchery outplants. Potential competitive interactions among naturally-spawned coho salmon and coho salmon from the captive breeding program would be reduced by releasing coho salmon into locations where the habitat capacity exceeds the requirements of the local naturally-spawning population.

5.7.6.2 Steelhead

The proposed steelhead isolated harvest program would contribute toward mitigation requirements and sustain a recreational steelhead fishery while minimizing effects on listed fish populations. As with the coho salmon program, hatchery protocols would be implemented to minimize genetic and ecological risks to the naturally-spawning steelhead population. Appropriate broodstock sampling and mating protocols would be implemented. Programs that rear fish through the smolt life-stage have a higher risk of artificial selection than those that release smaller fish. As described for coho salmon, new rearing techniques would reduce the risk of artificial selection. To reduce possible effects related to potential competitive interactions or predation, the hatchery program would release steelhead smolts in the same size range as wild smolts, and volitional release and acclimation would help reduce straying.

A future alternative integrated harvest program, which would use wild steelhead broodstock rather than only hatchery-reared fish, would significantly reduce the risk of genetic effects to the naturally-spawning population. The integrated harvest program may be implemented, if needed, to protect genetic integrity of steelhead in the Russian River. Potential benefits may also include reduction in short-term risk of extinction and increase in speed of recovery. By increasing the abundance of native steelhead, a vital component of the ecosystem would be restored. However, factors responsible for the original decline must be addressed.

5.7.6.3 Chinook Salmon

This BA currently proposes a "no production" program. Based on the current short-term abundance data for Chinook salmon, the Russian River spawning aggregate of the California Coastal Chinook ESU does not appear to be at immediate genetic risk, and indeed, it may be a self-sustaining population. This suggests that the "no production" alternative may result in the least genetic effect to the remaining Russian River Chinook salmon population.

A supplementation program could be implemented if population trends indicate that this action is needed to prevent the Russian River population of Chinook salmon from declining below the viable population threshold. Potential benefits of future supplementation programs include reduction in short-term risk of extinction, increase in speed of recovery, and restoration of ecosystem processes. By increasing the abundance of native Chinook salmon, a vital component of the ecosystem would be restored. Supplementation could help speed recovery through increased population abundance for Chinook salmon. However, factors responsible for the original decline (if one exists) must be addressed.

The loss of within-population diversity and outbreeding depression may be minimized by appropriate broodstock sampling and mating protocols. For the proposed future supplementation program, approved protocols for broodstock sampling and mating would be implemented. The future Chinook salmon program would incorporate new rearing techniques to reduce artificial selection, low-density rearing, and volitional-release programs to reduce competition and predation pressures on the local naturally-spawning population. Fish would be released into locations where the habitat capacity exceeds the requirements of the naturally-spawning population.

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This section integrates project effects by species and life-history stage to evaluate the overall effect on populations of each species. To integrate and assess effects of the proposed project, the timing and locations of operational activities are correlated with temporal and spatial characteristics of listed fish populations, including life-history strategy, habitat use, and geographical distribution. The following discussion tracks each species through their life-history in the Russian River to determine the interactions with the project and identify the potential collective effects. The effects of the individual actions were summarized in Section 5.7. This analysis focuses on the most important potential project effects, both positive and negative, to provide perspective on how the proposed project will affect the ability of the coho salmon, steelhead, and Chinook salmon to complete their lifecycles and contribute to future generations.

Chinook salmon use the Upper and Middle mainstem Russian River and Dry Creek for migration, spawning, and rearing, while coho salmon use the mainstem largely as a migration corridor. Coho salmon rely on tributaries for spawning and rearing. Steelhead use both the mainstem Russian River and tributary habitat for spawning and rearing. All three species can potentially use Dry Creek for spawning and rearing, but suitable coho salmon habitat is limited.

This analysis focuses on identifying the effects of proposed project actions on upstream migration, spawning/incubation, rearing, and emigration of the listed species. Limiting factors are identified, where known, so that key project effects, both negative and positive, can be identified. Effects are integrated over all life-history stages to determine the overall effect of the proposed project on salmonids and their habitat.

Project effects are classified into one of three categories:

- Negative effects that were identified under baseline operations, but which are reduced to minimal or no effect under the proposed project. The proposed project would, in these cases, provide a benefit over baseline conditions.
- Effects that may negatively affect salmonids or their habitat.
- Beneficial effects.

In each case, project effects are evaluated for improvements over baseline conditions and for their overall effect on populations of coho salmon, steelhead, and Chinook salmon and their habitats.

6.1 COHO SALMON

Coho salmon have a fixed 3-year lifecycle. Peak adult upstream migration generally occurs November through January. Spawning takes place from December to mid-February, and eggs can incubate as late as the end of March. Fry begin to emerge as early as February and as late as the first part of April, and juveniles spend approximately one year in freshwater tributaries before becoming smolts. Smolt emigration usually occurs between February and mid-May.

Coho salmon primarily use tributaries to the Lower Russian River and Dry Creek for spawning and rearing and use the mainstem for migration. Many of the tributaries that currently support coho salmon are downstream of the water diversion operations at Mirabel. These habitat-use patterns tend to separate coho salmon from some project operations. In some cases, potential project effects are low because coho salmon abundance is low and their distribution is limited.

An important limiting factor for coho salmon is rearing habitat. Survival during the rearing period is affected by such factors as water quality, flow rates, the amount of large woody debris in streams, and the size of riparian buffer zones. There are several project activities that should help improve rearing habitat in streams already occupied by coho salmon and in streams that could potentially support coho salmon populations in the future (e.g., tributaries to Dry Creek, Laguna De Santa Rosa, and Mark West Creek).

The proposed project has little opportunity to negatively affect returning adults, as current populations are primarily limited to a few tributaries. However, to reduce the chance of extirpation from the Russian River, coho salmon populations must eventually occupy a much greater number of tributaries in the basin (ENTRIX, Inc. 2003b). Thus, any project activities that improve conditions for upstream and downstream migration could play an important role in the recovery of viable coho salmon populations in the Russian River.

6.1.1 EFFECTS OF THE PROPOSED PROJECT ON COHO SALMON

In this section, project effects are integrated by life-history stage for coho salmon. In general, implementation of project activities is likely to either reduce negative effects relative to baseline conditions, or provide potential benefit. A few ongoing activities, however, could still adversely affect coho salmon, particularly downstream migration.

6.1.1.1 Upstream Migration

The proposed project should provide some benefit to coho salmon during the upstream migration period. Project activities that are expected to improve conditions for adult migration include the Flow Proposal (in Dry Creek), the habitat restoration programs, and maintenance practices in the flood control channels.

In the Russian River and Dry Creek, the proposed project flows would generally provide suitable conditions for upstream migration under *all* and *dry* water supply conditions. Temperature during the migration period is predicted to be suitable for adult migration more than 90 percent of the time. The Flow Proposal would improve conditions for upstream migration in upper Dry Creek relative to the current D1610 management scenario, which may help coho salmon recolonize tributaries in this area of the watershed.

Habitat restoration projects in tributaries to the Lower Russian River and Dry Creek would benefit fish passage to historic coho salmon streams. Instream structures in Dry Creek may slightly enhance passage to Dry Creek tributaries by providing increased cover from predators and creating pools to provide refuge for migrating adults during high flows. Habitat restoration projects in Santa Rosa Creek may also provide enhanced passage opportunities to high-quality spawning and rearing habitat in upstream areas. This may help offset potential negative effects due to channel maintenance activities in constructed channels in this portion of the watershed.

Restoration actions in the constructed flood control channels, such as planting native trees in riparian zones and installing instream structures, would help improve fish passage to historic coho streams in the Mark West Creek watershed. Channel reconstruction, bank stabilization, and riparian planting at the mouth of Big Austin Creek would also help increase access to prime coho salmon rearing and spawning habitat in East Austin, Gillian, and Willow creeks. While coho salmon are currently absent or in low abundance in the Mark West Creek and Big Austin Creek watersheds, these restoration projects should help facilitate the recolonization of historic coho salmon streams in the Lower Russian River. The ongoing effects of the project on upstream migration are currently negligible because they occur in reaches where coho salmon are currently absent. These effects could become more important in the future should the distribution of coho salmon populations increase. For instance, sediment maintenance activities in constructed flood control channels could pose a small risk to upstream migration in Santa Rosa Creek and Laguna de Santa Rosa (should they recolonize the Mark West Creek watershed). However, the effects of sedimentation on fish passage in this area should be offset by the proposed changes in channel maintenance practices. Thus overall, conditions for upstream migration is likely to improve in these streams relative to baseline conditions.

6.1.1.2 Spawning and Egg Incubation

Spawning and incubation habitat is less limiting for coho salmon in the Russian River than rearing habitat. Currently, spawning and incubation occur primarily in tributaries to the Lower Russian River mainstem, which for the most part are unlikely to be affected by project activities.

The proposed project should provide some benefit to coho salmon during spawning and incubation. Project activities that are expected to improve habitat conditions are the Flow Proposal and instream habitat restoration proposed for Dry Creek.

The Flow Proposal would provide improved spawning conditions for coho salmon in Dry Creek relative to current water management practices under D1610. This is especially true in upper Dry Creek, where daily flows are predicted to provide a higher frequency of suitable spawning and incubation flows relative to baseline, especially in *dry* water supply conditions and at full buildout demand.

Instream habitat projects planned for Dry Creek would also improve spawning and incubation conditions for coho salmon. These actions would increase the extent of riffles within channels that serve as prime spawning areas for coho salmon. Instream habitat structures, such as large woody debris, would also help reduce the chance of redd scour during storm events, thereby increasing the overall egg-to-fry survival rate.

6.1.1.3 Juvenile Rearing

Because coho salmon rear year-round, summer-rearing habitat is thought to be an important limiting factor for Russian River coho salmon. Much of the rearing habitat is currently located in tributaries in the Lower Russian River (e.g., Green Valley Creek and Maacama Creek). There are several project activities that would improve summer rearing conditions for juvenile coho salmon. These activities include the Flow Proposal in Dry Creek, habitat restoration projects, educational programs, changes in Estuary management, and water recycling programs.

The Flow Proposal would provide dramatically improved summer rearing conditions for coho salmon in Dry Creek relative to D1610, especially at buildout demand levels. Daily flows under the Flow Proposal are expected to provide good to optimal rearing conditions 90 to 95 percent of the time at current demand, and 75 to 80 percent of the time at buildout demand levels throughout Dry Creek. Under D1610, flows are expected to provide good juvenile rearing conditions less than 30 percent of the time. Given that summer rearing is often the limiting factor of coho salmon production in freshwater streams (Nickelson and Lawson 1998), the Flow Proposal should have important beneficial effects for the recovery of coho salmon in the Russian River.

Juvenile rearing habitat has also been marginal in Dry Creek and its tributaries due to high velocities, and a lack of large woody debris and other instream structures. The habitat improvement projects planned for this region would provide localized habitat complexity and benefit young coho salmon through the creation of scour, plunge, and backwater pools. Pool habitat is essential for juvenile survival because it provides a refuge for high flows, cover from predators, and suitable rearing temperatures.

Habitat improvement programs are targeted for other Russian River tributaries capable of supporting coho salmon. Riparian and instream restoration programs that benefit coho salmon have the highest priority for implementation. These types of projects provide localized improvements in rearing conditions and would increase the availability of good-quality coho salmon habitat. Habitats with a smaller potential to provide improved rearing conditions for coho salmon are the Estuary and the Upper Russian River; coho salmon have not been found in either location. If coho salmon populations increase, these areas could contribute positively to rearing opportunities and play an important role in the recovery of coho salmon in the Russian River watershed.

One of the most significant challenges for juvenile coho salmon is the removal or reduction of riparian vegetation along tributary streams. SCWA is actively engaged in several programs to help educate the public and local landowners to the importance of riparian corridors. For example, the North Bay Watershed Association program seeks to bring together farm organizations, environmental groups, and government agencies to develop a set of BMPs, develop TMDL regulations, explore the use of recycled water, institute pollution prevention, and other measures. The goals of this program are to restore and enhance the fish habitat in the Russian River watershed.

Under the Flow Proposal, summertime artificial breaching of the sandbar at the mouth of the Russian River would be eliminated. This would likely result in improvements in summer rearing habitat in the lagoon, which may benefit coho salmon. Many of the streams currently used by coho salmon are close to the Estuary. Young coho salmon in other systems move down out of their natal tributaries and may take up residence in the upper portion of the Estuary.

Finally, SCWA is developing a recycled water program to reduce the amount of surface flows used for agricultural irrigation. The recycled water would supplant the use of natural flows from tributaries, thereby improving summer rearing opportunities for coho salmon. This program would help improve flows in Dry Creek tributaries and Macaama Creek.

One potential negative effect of the project on juveniles is the operation of the Spring Lake flood control reservoir. The diversion inlet to the reservoir is located near good-quality spawning and rearing habitat on Santa Rosa Creek, so juveniles could become trapped in the reservoir during high-flow events. Although there are currently no known coho salmon populations in this area, restoration efforts to improve habitat in Santa Rosa Creek (and other streams in the Mark West Creek watershed) may result in expanding coho salmon distribution to the upper portion of Santa Rosa Creek. If coho salmon begin to use this area, young coho salmon could be affected by the diversion inlet. However, given that flooding occurs infrequently in the Spring Lake area, the overall risk to juvenile coho salmon would be low.

6.1.1.4 Juvenile Downstream Migration

The project would be expected to improve conditions for downstream migration of smolts relative to baseline operations. The greatest project benefits to coho salmon migration would be associated with proposed changes in operations in the Mirabel and Wohler areas.

In particular, the diversion structure and fish ladder on the west side of the inflatable dam would be modified to improve downstream fish passage. The addition of the notch in the inflatable dam would create a high-velocity flow field that would entrain juveniles and help them pass quickly over the dam, thereby minimizing migration delays. Yearly regrading of the Wohler infiltration ponds would also improve fish passage by directing smolts entrained during winter storms towards the inlet pipe, allowing them to quickly return to the river. Finally, upgrading fish screens at the intake structures at Mirabel and

Wohler to meet NOAA Fisheries criteria would reduce the chance of take during downstream migration.

Some potential risks remain for young coho salmon as they migrate downstream. During the first 8 hours after the inflatable dam is raised, there is a small risk of stranding smolts or exposing them to avian predation as flows are reduced in the reach just downstream of the dam. Smolts could still be delayed at the inflatable dam if they have difficulty locating the augmented flow channel through the notch. They could also fall prey to predatory fish in Wohler Pool or in Wohler infiltration ponds. Finally, entrapment is still possible in Spring Lake or the ponds at Riverfront Park. Both of these facilities are situated near coho salmon rearing habitat. Riverfront Park is located close to several quality coho salmon tributaries, including Mill and Felta creeks, while Spring Lake is located near potential coho salmon habitat on Santa Rosa Creek.

6.1.1.5 Fish Production Programs

One of the most significant benefits of the proposed project to coho salmon is the initiation of a supplementation program using the fish production facilities at DCFH. A coho salmon integrated recovery program, initiated by CDFG and NOAA Fisheries in 2001, would continue at DCFH, replacing previous baseline production goals of mitigating the loss of coho salmon habitat due to the construction of Warm Springs Dam.

The fish production program would rear juvenile coho salmon collected in the Russian River watershed, use them as broodstock, and seed progeny into streams in the Lower Russian River basin. The objectives of the captive broodstock program are to: 1) prevent extirpation of Russian River coho salmon, 2) preserve genetic, ecological, and behavioral attributes of Russian River coho salmon while minimizing potential effects to other stocks and species, and 3) build a naturally sustaining coho salmon population. This program could be very instrumental in helping juveniles recolonize historic coho salmon streams, leading to the long-term enhancement of coho salmon populations in the Russian River.

6.1.2 Coho Salmon Response to the Proposed Action

The overall beneficial effects of the proposed project are summarized in Table 6-1. In general, the project activities would improve habitat for coho salmon and should play an important role in the recovery of coho salmon populations in the Russian River. There are a few ongoing project activities that could negatively effect downstream migration. However, changes in these activities would improve outmigration over baseline conditions (Table 6-2).

Table 6-1 Potential Project Benefits to Coho Salmon

Life-History Stage	Project Benefits
Adult upstream migration	Implementation of the Flow Proposal in Dry Creek.
	Instream restoration projects that increase cover and high-flow velocity refuge to priority coho tributaries.
Spawning and incubation	Instream habitat structures in Dry Creek and other streams to help maintain spawning gravels.
Juvenile rearing	Implementation of the Flow Proposal in Dry Creek.
	Instream habitat improvements.
	Recycled water projects.
	Educating the public on the importance of riparian corridors.
Juvenile downstream migration	Fish screens at Mirabel diversion.
	Exit channel at Wohler infiltration pond.
	Notching of Wohler Dam.
All life stages	Captive Brood supplementation program.

Table 6-2 Potential Project Effects on Coho Salmon

Life-History Stage	Low Continued Risks
Juvenile downstream migration	Stranding during inflation of Mirabel Dam.
	Predation in Wohler Pool or infiltration pools.
	Entrapment at Riverfront Park lakes.
	High summer flows during *critically dry* years

6.1.2.1 Integration of Project Effects on Coho Salmon Habitat

Integration of the effects over all project activities indicates that habitat conditions for coho salmon would be improved throughout historic coho salmon streams in the Russian River watershed. Habitat improvements would affect all stages of the freshwater coho salmon lifecycle in a positive manner and should help facilitate their recovery.

Project activities that are most likely to benefit coho salmon are the instream habitat improvements and the Flow Proposal. These projects would have the greatest effect on rearing habitat and juvenile survival. This could have a profound effect on population growth rates because summer and over-wintering habitat are typically considered limiting factors for coho salmon in freshwater streams (Nickelson and Lawson 1998). Summer flows in Dry Creek at buildout during *critically dry* years would be improved over D1610, but may still be high for rearing coho salmon.

Instream restoration actions are most likely to have the most immediate effect on coho salmon abundance, as they are slated for tributaries in the Lower Russian River basin, including high-priority coho salmon streams (e.g., Green Valley, Felta, Dutch Bill, Turtle, and Big Austin creeks). These actions include placing large woody debris or other instream structures in streams to create more pool habitat where juveniles can rear. Additional actions include planting riparian vegetation to provide protective cover from predators, reduce water temperatures, and provide additional habitat for invertebrates.

The implementation of the Flow Proposal in Dry Creek would improve rearing conditions, especially in the Upper Reach, and could help facilitate the recovery of viable coho salmon populations in Dry Creek and its tributaries. The Flow Proposal would also provide better conditions for spawning and upstream migration, increasing the probability that abundances in this region would increase in the future.

Other project activities that would improve rearing conditions over baseline include public education on the importance of riparian corridors, and the use of recycled water for agriculture.

Several proposed project actions would improve conditions for upstream and downstream migration, including modifying the fish screens at the Mirabel diversion, adjusting operations of the Mirabel inflatable dam, creating an exit channel at the Wohler infiltration pond, and creating a notch in the Mirabel inflatable dam. These actions would reduce habitat fragmentation by allowing coho salmon to more easily access historic coho salmon tributaries in the Lower Russian River and Dry Creek. This would increase the amount of rearing and spawning habitat available to coho salmon in the Russian River basin. Given that habitat destruction is a primary cause of species decline, increasing the quality of migration habitat to quality coho salmon tributaries (i.e., improving habitat connectivity) is an important step in the recovery process.

The quality of spawning habitat would also improve as a result of instream project activities. In particular, SCWA would add instream structures at suitable locations in Dry Creek to increase habitat complexity and to capture and hold coho salmon spawning gravels. This should increase the amount of riffle habitat preferred by coho salmon for spawning and help reduce redd scour.

Finally, implementation of the captive broodstock program would help prevent extirpation and increase the distribution of coho salmon in the Russian River basin. Currently, low abundances of returning adults leave coho salmon vulnerable to extinction risks associated with demographic and environmental stochasticity. Given the high potential for inbreeding depression in traditional hatchery programs, supplementation via a captive broodstock program may provide the best option for building up local coho salmon populations, while preserving the genetic variability found within the Russian River watershed. The captive broodstock program would help reverse declining trends in coho salmon and facilitate the recolonization of barren coho salmon streams with good-quality coho salmon habitat.

Although project activities are expected to improve downstream migration relative to baseline conditions, there would still be potential ongoing negative effects that could impede smolt migration. For instance, there would still be a risk of entrapment in the Riverfront Park lakes and the Spring Lake flood control reservoir. The risk would be greatest for the Riverfront Park lakes, because they are located near coho salmon migration corridors in the lower mainstem and are frequently overtopped by flood flows. Other possible risks to juveniles during downstream migration include stranding during the inflation of the Mirabel dam and an increased risk of predation for fish swept into the Wohler infiltration pools.

Given the overall improvements to rearing habitat and fish passage, as well as the implementation of the broodstock program, any lingering negative effects due to the flood control reservoirs and the pools at Wohler should be relatively small. The effect of entrapment and stranding along the mainstem corridor could be seen as marginally reducing the survival rate of smolts in more upstream tributaries. However, given the proposed improvements at the diversion facilities, the chance of having viable populations in Dry Creek and the Mark West Creek watershed should improve. Combined with improvements in habitat conditions, the Flow Proposal, and the captive broodstock program, the distribution and abundance of coho salmon in the Russian River should increase.

6.2 STEELHEAD

Unlike coho salmon, steelhead do not have a fixed 3-year lifecycle. They typically spend 2 years in the ocean before returning to spawn, and may return to the ocean after spawning to spawn again in a later year. Peak adult upstream migration occurs from January through March.

Steelhead usually spend 1 or 2 years rearing in fresh water, but can remain for longer periods of time before migrating to the ocean. Steelhead rear year-round in the tributaries and throughout the Middle and Upper mainstem. Their distribution is widespread in the Russian River watershed, including Dry Creek and its tributaries.

While some juveniles rear in the Lower mainstem before smolt outmigration, summer water temperatures in much of this region are too warm to provide suitable conditions for juveniles in most years. Tributaries in the Lower reaches tend to provide less vegetative cover, are often wide and shallow, and have little riparian vegetation. Water temperatures in the mainstem near the coast are cooler, and the Estuary may provide year-round rearing habitat.

Because steelhead use so much of the Russian River watershed, the proposed project has the opportunity to affect all lifestages and their habitat; however, the greatest effect would likely occur during juvenile rearing. Some of the most important project effects are related to summer rearing habitat in the Upper Russian River, Dry Creek, and the Estuary, which can be influenced by water management and by operations at the dams.

Channel maintenance activities in portions of the Central Sonoma Watershed Project and the Mark West Creek watershed have the potential to affect rearing, passage, and habitat conditions. However, many of the constructed flood control channels, particularly in the Rohnert Park-Cotati area, do not provide good rearing habitat for steelhead. The primary effect of channel maintenance in these areas, particularly in the Santa Rosa Creek watershed and tributaries to Mark West Creek, would be on migration to steelhead habitat located upstream of the constructed channels. In those channel reaches that have the potential to support steelhead rearing (e.g. the nine channels identified in Section 5.4.2.2 that would be maintained with the original design maintenance scenario), channel maintenance activities may negatively affect steelhead habitat.

The integrated harvest program at DCFH and CVFF may have genetic and ecological effects on the naturally-spawning steelhead population. Implementation of a future integrated harvest program could potentially reduce some of these effects.

Localized effects may occur if individual adult or juvenile salmonids become entrained into the Riverfront Park lakes or Spring Lake (off Santa Rosa Creek) during high-flow events. Also, Mirabel/Wohler diversion facility operation and maintenance activities in the mainstem could affect salmonids, although improvements to the operations of these facilities should significantly reduce the risk of entrapment. Finally, localized habitat alterations in the mainstem could be affected by channel maintenance activities related to streambank erosion control activities.

Several project activities would benefit steelhead. For instance, the Flow Proposal would benefit summer rearing habitat in the Upper and Middle Russian River, as well as in the Estuary. Restoration actions in affected areas, including Dry Creek and tributaries in the Santa Rosa and Mark West creek watersheds, would have benefits for spawning and rearing habitat that could help to offset project effects from activities such as channel maintenance. Restoration actions in other tributaries, as well as watershed management activities, would likely contribute to the recovery of the species. Cumulatively, these proposals could provide an increase in steelhead production during the freshwater period.

6.2.1 EFFECTS OF THE PROPOSED PROJECT ON STEELHEAD

In this section, project effects are integrated by life-history stage. Implementation of several project activities would likely either reduce negative effects relative to baseline conditions or provide potential benefit. Some ongoing activities, however, could still adversely affect steelhead and their habitat, particularly juvenile rearing and downstream migration.

6.2.1.1 Adult Upstream Migration

The proposed project should provide some benefit to steelhead during the upstream migration period. While there is the potential for some injury to individual fish and alteration of habitat, project activities would improve migration success for steelhead overall, relative to baseline conditions. Project activities that are expected to improve conditions for adult migration include the Flow Proposal (in Dry Creek), operations at Wohler and Mirabel infiltration ponds, habitat restoration programs, and maintenance practices in the flood control channels.

In the Russian River, implementation of the Flow Proposal would provide flows for upstream migration similar to the current D1610 management scenario. Daily flows for upstream migration in the mainstem are predicted to be suitable about 65 to 75 percent of the time under current and buildout demand levels. Because upstream migration is generally cued by appropriate high flows, there are more than enough opportunities for steelhead to migrate upstream. The Flow Proposal also is expected to provide a high frequency of suitable flows for upstream migration in the upper portion of Dry Creek under *all* water supply conditions, which could enable more adult steelhead to reach suitable spawning areas in this region. Under the Flow Proposal, temperature would not be a problem for steelhead during the migration period. Thus the Flow Proposal should ensure good passage conditions throughout the Russian River.

Project changes to operations of the Wohler infiltration ponds, as well as fish rescues (primarily in the Mirabel ponds), would reduce the risk of entrapment for migrating steelhead. As described for coho salmon, there would be a small risk of entrapment at the Riverfront Park lakes (upstream of the Mirabel/Wohler area) and at Spring Lake (off of Santa Rosa Creek). However, because flooding of these reservoirs is infrequent, the overall risk to the population is low.

Habitat restoration projects in tributaries, including Dry Creek, would benefit fish passage. Instream structures in Dry Creek may slightly enhance passage to Dry Creek tributaries. Much attention has been given to restoration actions in Santa Rosa Creek in recent years. These projects improve habitat within the restored section in Santa Rosa Creek and provide enhanced passage opportunities to high-quality spawning and rearing habitat in upstream areas. This may help offset potential negative effects due to channel maintenance activities in constructed channels in this portion of the watershed.

The proposed project would reduce sediment and vegetation maintenance activities in constructed and natural flood control channels. Increases in riparian vegetation would improve conditions for fish passage through these channels by creating more habitat complexity and increasing the abundance of invertebrate prey. This would provide a greater opportunity for adult steelhead to reach upstream spawning and rearing habitat, especially in the Mark West Creek watershed.

Sediment maintenance activities in constructed flood control channels could pose a small risk to migration. While many flood control channels are of limited value for steelhead, good-quality habitat is located upstream of these channels in the Santa Rosa and Mark West Creek watersheds. The constructed flood control channels that are most likely to require substantial maintenance (including original design vegetation maintenance protocol) also provide passage to spawning and rearing habitat in Paulin, Piner, and Santa Rosa creeks. Channels that contain upstream rearing habitat only include Brush, Crane, Laguna de Santa Rosa, Rinconanda, and Todd creeks. In general, fish passage to these areas would continue to be affected by ongoing maintenance activities in the flood control channels; however, changes in maintenance practices would improve passage conditions relative to baseline.

6.2.1.2 Spawning and Egg Incubation

Flow conditions for spawning and incubation in the Russian River mainstem could pose a small risk to steelhead. Flows at this time of year are controlled primarily by natural runoff and storm events rather than through water management. Therefore, it is expected that the Flow Proposal and D1610 would provide similar conditions for spawning and incubation. As a result of precipitation patterns in the Russian River, flows are generally too high for steelhead during this lifestage. Under *all* water supply conditions, good flows occur 15 to 25 percent of the time, with favorable flows occurring more frequently upstream, near Ukiah. The flow rates improve under *dry* water supply conditions, with good to optimal spawning and incubation flows occurring 25 to 40 percent of the time. Because flows are relatively high during spawning and remain high for most of the incubation period, redd scour could effect embryo survival success. Redd desiccation may also occur during the natural recession of flow, but is probably limited to small, localized areas.

In Dry Creek, the Flow Proposal provides slightly better overall conditions for spawning under *dry* water supply conditions, while D1610 is predicted to provide slightly better flows under *all* water supply conditions. Overall, flows in Dry Creek would be much more suitable for spawning and incubation compared to the Russian River mainstem. In general, the Flow Proposal would provide similar flows relative to baseline conditions, however, this effect is due to natural runoff patterns rather than project operations. During this portion of the year, the operation of Coyote Valley and Warm Springs dams has a very limited influence on flows.

Reductions in gravel-bar grading and vegetation maintenance activities related to streambank stabilization would be implemented to counter risks associated with high flows during the spawning and incubation period. This would help increase the amount of velocity refugia available to steelhead in the middle and upper mainstem, and should reduce the risk of redd scour while ensuring adequate delivery of DO to incubating embryos. The project would schedule stabilization activities later in the summer, after the incubation period is over. This practice should improve spawning and winter rearing conditions in the mainstem, which is important habitat for steelhead production. Rearing juveniles have higher growth rates in the mainstem relative to the tributaries, due to an increased abundance of invertebrates living in the Russian River (Chase et al. 2002). Since larger juveniles have higher ocean survival rates, they are more likely to contribute to future generations than steelhead reared in the tributaries.

Habitat restoration actions in Dry Creek, including instream and bank stabilization projects in tributaries, would also provide a benefit for steelhead spawning and incubation. These actions would improve habitat in Dry Creek and other tributaries by increasing the amount of pools and riffles within channels that would serve as prime spawning areas for steelhead.

6.2.1.3 Juvenile Rearing

As juveniles rear year round in freshwater streams, the amount of summer rearing habitat is an important limiting factor affecting the recovery of Russian River steelhead. The proposed project has the potential to substantially improve rearing habitat by improving summer rearing flows in the Upper Russian River and Dry Creek, implementing a low-flow Estuary management program, and minimizing impacts to juveniles from construction and maintenance activities.

The Flow Proposal would result in improved summer rearing conditions on the upper mainstem Russian River, where some of the best rearing habitat occurs. Summer rearing flows under the Flow Proposal would provide lower water velocities in riffles and runs, especially between Ukiah and Cloverdale. Daily flows during June through October are predicted to provide good conditions for steelhead rearing 85 percent of the time under current and buildout demand levels. Under *dry* water supply conditions, the Flow Proposal and D1610 provide similar flows, yielding good rearing conditions over 90 percent of the time. The lower flows produced by the Flow Proposal under *all* water supply conditions would provide more suitable velocities for juvenile fish to hold in, while maintaining a steady supply of food and providing good juxtaposition of these velocities with cover elements within the river.

The benefits of the Flow Proposal would be more pronounced in Dry Creek. The Flow Proposal would result in reduced flows relative to D1610, thereby providing a substantial benefit to rearing steelhead during the summer months. Under *all* water supply conditions, daily flows would be good to optimal for rearing about 90 percent of the time compared to 34 to 55 percent of the time under current baseline management practices. Under *dry* water conditions, the Flow Proposal provides similar conditions for rearing, while flows under D1610 get worse. These improvements in rearing flows should help increase steelhead abundance throughout Dry Creek.

Implementation of the low-flow management of the Estuary would eliminate artificial breaching of the sandbar at the river mouth during the summer. This would benefit juvenile steelhead by improving water quality and temperature, assuring adequate water levels, increasing shoreline vegetation, and stabilizing the invertebrate food supply (Smith 1990). Overall, this would increase the amount of rearing habitat available to steelhead in the lower Russian River and would improve summer rearing conditions relative to the current D1610 management scenario. The proposed changes in gravel-bar grading and vegetation removal practices (conducted for streambank stabilization in the Russian River) have the potential to improve winter-rearing habitat relative to baseline conditions. In general, these activities would be scheduled to occur at one location at a time, to ensure that plenty of undisturbed rearing habitat remains available to support steelhead in the mainstem. While some local alterations to winter (and summer) habitat would occur during gravel-bar grading and vegetation removal, these alterations would not likely affect steelhead populations. Channel maintenance activities in constructed flood control channels that have the potential to support steelhead rearing, such as Santa Rosa Creek (see Section 5.4.2.2), may continue to negatively affect steelhead rearing habitat.

Proposed maintenance activities at Coyote Valley Dam would also likely improve rearing habitat for steelhead over baseline conditions. The potential to strand steelhead fry downstream of Coyote Valley Dam during maintenance would be reduced by decreasing ramping rates, providing 25-cfs bypass flows, and scheduling inspection and maintenance activities between July 15 and October 15. Because there is good summer rearing habitat in the Upper Russian River, these measures could help increase juvenile abundance in the mainstem.

Project activities in the Mirabel and Wohler area of the Russian River may provide some benefit to juvenile steelhead; however, this benefit is likely to be small, as steelhead generally rear further upstream. Fish screens at the Mirabel and Wohler diversion facilities would reduce the risk for entrainment and impingement to a very low level. A reduction in the ramping rate of the inflatable dam at Mirabel would reduce the risk of stranding. Additionally, gravel-bar grading in the Wohler/Mirabel aquifer is expected to reduce the risk of entrapment to a low level.

Finally, the monitoring component of the project (e.g., SCWA monitoring study at the inflatable dam, population monitoring over multiple years in selected tributaries, and 2002 steelhead distribution study in the mainstem) would yield valuable data on the status of steelhead. These data are crucial for informed management decisions that support recovery efforts. Watershed management activities that lead to improved habitat conditions in the watershed (e.g., Fish Friendly Farming program, *Arundo* control efforts, and funding for KRIS database coordination) help support recovery efforts. Coordination with public and private entities, as well as the local community, helps to focus limited resources where they would do the most good. Although the effects of these actions are difficult to quantify, cumulatively they are likely to help sustain recovery efforts within the watershed.

6.2.1.4 Juvenile Downstream Migration

Project activities that affect passage conditions in the Russian River mainstem are most likely to affect downstream migration of juvenile steelhead. The greatest project benefits to steelhead migration are similar to those for coho salmon and are associated with changes in operations in the Mirabel and Wohler area. Project activities that are expected to improve conditions for downstream migration include the diversion structure and fish ladder at Mirabel, the notch in the inflatable dam, the regrading of the Wohler infiltration ponds, and upgrading the fish screens at the diversion intake structures (see Section 4.2). Some components of the proposed project in the Mirabel/Wohler region have the potential to directly affect migrating juveniles. For instance, when the infiltration ponds overtop, entrained smolts could become stressed and/or die, even with the proposed improvements and regrading activities. Inflation or deflation of the inflatable dam at Mirabel has the potential to strand juvenile fish; however, the proposed reduction in the ramping rate during the inflation process would substantially reduce this risk. Finally, there is the potential for smolts to become entrained in Spring Lake or Riverfront Park lakes during high-flow events. However, given the low probability of such an event occurring, the risk to young steelhead is relatively low.

Juvenile steelhead must pass through the Estuary in order to reach the sea. Since most smolts migrate during the early part of the year, when the Estuary is still open to the ocean, potential effects on outmigration would likely be minimal. Negative effects could occur during *critically dry* years when low flows may result in spring sandbar closures.

However, if habitat conditions in the lagoon are good, juvenile fish may benefit from additional rearing time in a food-rich environment that may develop in the lagoon.

6.2.1.5 Fish Production Programs

The project will continue to operate a hatchery program to stock the Russian River with steelhead for recreational fishing. Because of the uncertainty in the level of genetic divergence between the natural and hatchery-reared steelhead within the basin, the fishery will be operated as an isolated harvest program. The program will collect returning hatchery-reared steelhead and use them as broodstock to produce juveniles. This will help minimize ecological interactions with wild Russian River steelhead populations, while mitigating for the loss of steelhead habitat due to the construction of the Warm Springs and Coyote Valley Dams.

The proposed operation of the DCFH and CVFF hatcheries could pose a small genetic and/or ecological risk to the naturally-spawning populations. Angling for hatchery-produced fish could also result in incidental harm or mortality of naturally-spawned steelhead. To reduce the effects of the hatcheries on wild steelhead, USACE would evaluate the effectiveness of an integrated harvest program, which would incorporate naturally-spawned steelhead into hatchery broodstock, on maintaining genetic diversity. By combining hatchery and naturally-spawning populations, managers may be able to increase genetic diversity in hatchery-raised fish, so that they are more adapted to local physical conditions. If successful, this program could be used to supplement Russian River steelhead, should natural populations begin to decline. Implementation of a future integrated recovery/harvest program at the DCFH and CVFF could help recovery efforts for the naturally-spawning population if data indicate it is warranted. Overall, implementation of the integrated hatchery program should reduce genetic and ecological risks to wild and hatchery steelhead.

6.2.2 INTEGRATION OF EFFECTS

Of the three listed salmonid species in the Russian River system, steelhead are the most widespread and possibly abundant. As a result, steelhead may be influenced by the full range of environmental effects produced through project activities associated with channel maintenance and water management operations in the watershed. Steelhead also have a protracted freshwater rearing phase lasting up to two years or more and, unlike coho salmon and Chinook salmon, do not have a relatively fixed three-year lifecycle. This means that juveniles will be influenced by activities in the river and the watershed for much longer; hence, project activities can affect all lifestages and the habitats associated with them.

Overall, under the proposed project, the environmental conditions in the Russian River system would likely be beneficial to the continued survival of steelhead in the river system, and stocks would likely improve compared to baseline conditions (Table 6-3). There would be relatively few direct effects on steelhead mortality associated with the proposed project, and the few effects that could occur would likely be small and localized. Most of the effects on steelhead would arise as a result of project activities on habitat conditions, which in turn could influence the various lifestages (Table 6-4).

One potential difficulty when evaluating the possible effects of any human activities on the various lifestages of salmonids in river systems is in identifying possible "bottlenecks" that may limit salmonid production in freshwater (Reeves et al. 1991). The importance of biological monitoring and research programs in this process should not be underestimated (Karr and Chu 1998). In this regard, the SCWA monitoring studies at

Table 6-3 Potential Project Benefits to Steelhead

Life-History Stage	Project Benefits
Adult upstream migration	Fish passage projects would improve access to upstream habitat.
Spawning and incubation	Instream habitat structures in Dry Creek would help maintain spawning gravels.
Juvenile rearing	The Flow Proposal would improve flows for summer rearing in Dry Creek and the Upper and Middle Russian River.
	Elimination of summertime artificial breaching of the sandbar would improve summer rearing in the lagoon.
	Recycled-water projects would improve conditions in selected tributaries.
	Watershed management activities and data collected in studies and monitoring programs would support management decisions.
	Instream habitat structures in Dry Creek would help maintain spawning gravels.
Juvenile downstream migration	Improved fish screens, modifications at fish ladder, and notch in inflatable dam would improve passage.
	Exit channel at Wohler infiltration pond, regrading of ponds at Wohler and Mirabel diversions reduce risk of entrapment.

Table 6-4 Potential Project Effects on Steelhead

Life-History Stage	Low Continued Risks
Juvenile downstream migration	Stranding during inflation of Mirabel inflatable dam.
	Entrapment in Mirabel or Wohler infiltration ponds. Risk reduced to very low level.
	Entrapment in Riverfront Park lakes and Spring Lake.
Juvenile rearing	Gravel-bar grading and vegetation maintenance in the mainstem would affect habitat. Protocols would be implemented to reduce effects from baseline.
	Channel maintenance in several constructed flood control channels that have the potential to support juvenile rearing may reduce habitat value.
Adult migration	Sediment and vegetation maintenance in constructed flood control channels may reduce upstream and downstream passage to and from good quality habitat upstream.

Mirabel, population monitoring over many years in selected tributaries, as well as the mainstem snorkel survey carried out in fall 2002, have yielded important information about the status of steelhead in the watershed, which is needed to make effective management decisions.

The primary effect of the Flow Proposal in the Russian River would be to improve steelhead summer rearing habitat by reducing summer flows relative to D1610. This is especially true in the area between Cloverdale and the Forks, which provides the best steelhead rearing habitat in the mainstem. Reduced flows in Dry Creek would provide a substantial benefit to rearing steelhead during the summer months relative to current management under D1610. In general, the improved rearing flows throughout the Russian River basin could result in a marked increase in juvenile survival. This increase in survival should translate into future increases in adult abundance and a reduced risk of population extinction.

There is the potential for considerable positive effects on steelhead spawning and rearing from the habitat restoration projects currently being carried out throughout the watershed, and which will continue as part of the proposed project. Stream habitat improvement is now an established and proven discipline in river management programs, and has been shown to alleviate, restore, and mitigate the adverse changes produced through land and water resource development projects (Reeves et al. 1991; Wissmar and Bisson 2003). Habitat improvement programs can both revitalize natural river features, such as the pool-riffle pattern, and lead to an overall increase in habitat diversity, which is an essential habitat requirement in the population ecology of listed salmonids. The clear and direct correlation between the level of instream habitat diversity and levels of stream fish abundance are well documented in the scientific literature (Hicks et al. 1991). The widespread habitat restoration programs being undertaken in the Russian River watershed would continue to improve habitat, and help counteract any possible detrimental effects of other operations and maintenance activities.

The implementation of a future integrated recovery/harvest program at the DCFH and CVFF may also help recovery efforts of naturally-spawning population if data indicate it is warranted. Genetic and ecological risks from an isolated harvest program may be reduced with the implementation of an integrated hatchery program.

In addition to suitable spawning, incubation, and rearing habitat, steelhead populations also require unrestricted migratory corridors for both adults and juveniles (Bjornn and Reiser 1991). Project activities associated with the improvements of fish screens at Mirabel, the grading of the Wohler infiltration ponds, and modifications to maintenance activities in the flood control channels should allow improved passage relative to baseline for both juvenile and adult steelhead. This could help increase the number of adults that spawn in upstream channels and improve the survival rate of juveniles as they migrate to the sea.

Other project activities that would benefit steelhead include the changes to the ramping rates at Coyote Valley and Warm Springs dams, elimination of summertime artificial breaching of the sandbar, and recycled water projects. These activities would reduce the chance of take due to stranding of juveniles and help improve water quality in rearing habitat.

There are still some ongoing risks to steelhead in the Russian River. These risks are primarily associated with migration. The biggest risk to migrating juveniles would be entrapment in Riverfront Park and Spring Lake reservoirs during flood events. Entrapment in Mirabel or Wohler infiltration ponds would also be possible and could lead to migration delays and an increased chance of predation. There would also be the possibility that juveniles could become stranded during inflation of the Mirabel Dam. For migrating adults, sediment and vegetation maintenance in constructed flood control channels could reduce passage to good-quality habitat upstream. In reaches of constructed flood control channels with the potential to support rearing salmonids (such as Santa Rosa Creek), channel maintenance activities may reduce the habitat value for rearing salmonids. In general, the risks to steelhead from these project activities would be small and would not change from baseline conditions. Given the overall benefits of the project for steelhead, any loss of individuals due to these activities should be more than made up for by the beneficial effects associated with the project.

6.3 CHINOOK SALMON

Early adult Chinook salmon have returned to the Russian River as early as mid-August. The peak run generally begins in October or November, and upstream migration continues into mid-January. Spawning takes place from November through January. Eggs incubate for a longer period than for coho salmon and steelhead, and the incubation period occurs from November through March. After emerging from the gravel, juvenile Chinook salmon rear in fresh water for only two to four months (February through May) before migrating downstream (February through June), compared to the more protracted freshwater rearing (1 to 2 years) of coho salmon and steelhead. Therefore, there is a relatively short time-period (November through June) during which fry and juveniles are susceptible to the negative and positive effects of the proposed project.

Adult Chinook salmon spawning habitat is located primarily in the Upper and Middle Russian River mainstem and in selected tributaries such as Dry Creek. A redd survey conducted in the mainstem in 2002 documented spawning as far downstream as Healdsburg (Cook 2003b). Chinook salmon rearing occurs in the Russian River mainstem, selected tributaries such as Dry Creek, and the Estuary.

One of the most beneficial components of the proposed project is SCWA's data collection effort. Monitoring studies and genetic studies are producing data that are crucial to informed management decisions for Chinook salmon recovery. Benefits would also be realized for spawning Chinook salmon by eliminating summertime artificial breaching of the sandbar, which would prevent early migrants from entering the river prematurely. Elimination of the Chinook salmon production program at DCFH would eliminate risks associated with hatchery production, although an integrated recovery program at the hatchery could be readily implemented in the future, if needed. Finally, habitat restoration actions in Dry Creek or other tributaries would benefit Chinook salmon.

The proposed project would have some limited opportunity to negatively affect salmon except in small, localized areas. Specific localized risks include entrainment at the Mirabel infiltration pond and the Riverfront Parks property, and sedimentation and injury to individuals from bank stabilization activities in the mainstem Russian River. The project would not likely affect spawning and egg incubation.

The most substantial effects, negative and beneficial, would likely occur for juvenile rearing in the mainstem and in Dry Creek from water management operations at the dams and channel maintenance activities in the mainstem. Important project effects would also be related to interactions between downstream migrants and the diversion facilities and infiltration ponds, many of which would be improved over baseline conditions.

6.3.1 Effects of the Proposed Project on Chinook Salmon

6.3.1.1 Fish Production Facilities and Other Restoration Actions that Affect all Life-History Stages

One of the most important components of the proposed project is SCWA's data collection effort. Monitoring conducted to assess project effects and studies conducted as part of restoration actions are producing data that will lead to informed, effective management decisions for Chinook salmon recovery.

SCWA monitoring data at the Mirabel inflatable dam indicate there is a relatively strong spawning run in the Russian River. In the year 2000, SCWA monitored the entire Chinook salmon run for the first time, and estimated a run of approximately 1,500 fish. A partial run count of 1,299 adult salmon through November 13, 2001 suggests the 2001 run was substantially larger than the previous year. A total of 5,466 adult Chinook salmon were observed in 2002, and 6,083 adults were observed in 2003. Data collected during a 2002 redd count and during smolt trapping studies at Mirabel indicate juvenile Chinook salmon production has increased in recent years.

Although long-term data are needed to accurately document population trends, recently collected data are providing information for management decisions, such as halting Chinook salmon hatchery production at this time. SCWA-funded genetic studies conducted at the Bodega Marine Laboratory determined that the naturally-spawning population is not immediately at risk of inbreeding, and that genetically, the existing population may represent a component of a diverse set of local populations.

Since hatchery production of Chinook salmon would not occur under the proposed project, potential genetic and ecological risks associated with baseline hatchery production would be eliminated. If new information indicates that populations were declining, an integrated recovery (supplementation) program would be implemented for Chinook salmon. Protocols would be implemented to minimize risks of hatchery production to the fullest extent possible. The benefits to recovery of the species would likely outweigh potential risks of genetic and ecological effects of hatchery production.

6.3.1.2 Adult Upstream Migration

The proposed project would likely have only small, localized effects on Chinook salmon upstream migration. The most important direct effects are associated with management of the Estuary as a closed system, the entrainment of adults into the Mirabel infiltration ponds or Riverfront Park lakes, and any incidental take due to fishing. Alterations to habitat under the Flow Proposal could also affect migration. Another proposed action that could benefit Chinook salmon upstream migration is the flood control flow management at Lake Mendocino. Water releases from Coyote Valley Dam would occur from mid to late October, and would augment flows in the Russian River. These flows may open the mouth of the River. Channel maintenance activities in the mainstem may also alter habitat somewhat, but are not expected to impede migration of spawners.

Direct effects to Chinook adults may include a risk of entrainment into the Mirabel and Wohler infiltration ponds. However, the risk of injury or mortality is low. The risk is slightly higher for the Riverfront Parks lakes, but even in these regions, the frequency of flood flows sufficient to entrain salmon is low. Chinook salmon may also be affected by incidental harvest bycatch and hooking mortality as a result of the proposed steelhead fish production program at DCFH and CVFF. Cumulatively, the risk to the population from these direct effects is likely to be low.

The Flow Proposal is designed to protect juvenile steelhead rearing habitat, and to allow the Estuary to be managed as a closed system. When the Estuary is managed in this fashion, Chinook salmon would be unable to enter the river until the onset of the rainy season, or until the USACE begins releasing additional water from the reservoirs to bring them down to flood control stage for the winter (generally in mid-October). This would benefit Chinook salmon by preventing them from entering the river during August and September, when flows are low and temperatures are warm.

Flow conditions in November through January for migrating adults would be generally similar between D1610 and the Flow Proposal under *all* water supply conditions, with daily flows suitable for passage about 77 percent of the time near Healdsburg, and 87 percent of the time in the Upper Russian River (Ukiah). In *dry* water supply conditions, the Flow Proposal provides better upstream migration conditions downstream of Cloverdale, with suitable flows predicted to occur about 60 percent of the time compared to 40 percent of the time for D1610. Since stressful water temperatures can occur in the mainstem in August and September, the Flow Proposal would provide better overall conditions for upstream migration relative to baseline conditions.

Both water management scenarios provide similar conditions for upstream migration under all water supply conditions, however, under *dry* water supply conditions, D1610 provides slightly better upstream migration conditions than the Flow Proposal for current and buildout demand levels. This decrease in flow in *dry* water years is the result of lower flows during October, which are designed to improve juvenile rearing habitat for coho salmon and steelhead in Dry Creek. However, upstream migration opportunities (78 percent of the time) would be plentiful under the Flow Proposal, particularly during the peak spawning migration period. Excellent temperature and DO conditions for all lifestages of Chinook salmon would occur under D1610 and the Flow Proposal.

Channel maintenance, particularly gravel-bar grading and vegetation removal for streambank stabilization, would result in habitat alterations. Under the proposed project, the level of work would be reduced and protocols to reduce the effects to salmonid habitat would be implemented. This would reduce the overall effect to Chinook salmon over baseline conditions. Conditions have been, and would likely continue to be, suitable for upstream migration in the mainstem.

Habitat restoration actions would have some limited benefits to upstream migration, particularly fish passage projects that may improve access to upstream spawning and rearing habitat. Primary spawning habitat is likely to be found in the mainstem, Dry Creek, and the lower reaches of tributaries, so the benefit to Chinook salmon upstream migration may not be substantial. However, restoration actions that improve the interconnectivity of habitat and that restore upstream habitat are likely to result in benefits to Chinook habitat.

In summary, the proposed project would likely have only small, localized effects on Chinook salmon upstream migration. The proposed Estuary management portion of the Flow Proposal would benefit Chinook salmon by keeping them from entering the river in August and September, when flows and temperatures are unsuitable. Direct effects to individual adult fish could occur in that fish could occasionally be entrained in the Riverfront Park lakes or be subject to incidental fishing pressure related to the proposed steelhead production program. However, the risk to the population is likely to be low. The proposed project would reduce the risk of entrainment at the Mirabel and Wohler diversions. Suitable habitat conditions would be available for upstream passage during the peak migration period through the Estuary, in the mainstem, and in Dry Creek. Flows under the Flow Proposal would be similar to baseline conditions from November through January and would not substantially affect adult Chinook migration habitat, in itself. Instream restoration actions could also have some small benefits for upstream migration.

6.3.1.3 Spawning and Egg Incubation

Spawning and egg incubation occur in the upper and middle sections of the Russian River, as well as in Dry Creek. The Flow Proposal would not change flow-related habitat or water temperature conditions during these periods in the Russian River mainstem or in Dry Creek. The proposed project would not likely have direct effects on Chinook salmon spawning or incubation. Habitat in the mainstem may potentially be affected by channel maintenance (gravel-bar grading and vegetation maintenance) related to streambank erosion control. Some benefits may be realized by restoration actions.

Gravel-bar grading and creation of overflow channels would affect the geomorphology of the channel by decreasing sinuosity and reducing hydraulic diversity and associated aquatic habitat diversity. Gravel-bar grading is closely interrelated with removal of vegetation on bars, which may reduce the extent of cover and lead to increased water temperatures, which may also affect the survival of incubating eggs. However, the proposed project would reduce effects to Chinook salmon habitat over baseline conditions.

Habitat restoration actions that reduce streambank erosion and sediment runoff would reduce sedimentation of downstream spawning and incubation habitat. Restoration actions in Dry Creek would also improve spawning and incubation habitat.

In summary, the proposed project is not likely to degrade conditions for spawning and egg incubation in the Upper Russian River or in Dry Creek over baseline conditions, and in some cases, it would improve them. Data from SCWA monitoring at the Mirabel inflatable dam and a redd survey conducted in the fall of 2002 indicate that under baseline conditions, successful spawning and incubation occurs upstream. Because negative effects would be reduced from baseline conditions, there would likely be a small net benefit in the quality of Chinook salmon spawning and incubation habitat over baseline conditions.

6.3.1.4 Fry and Juvenile Rearing

Of all the lifestages, the project is most likely to affect fry and juvenile rearing and downstream migration. Implementation of the Flow Proposal would improve rearing habitat in Dry Creek, particularly during drought years.

One of the most substantial benefits to fry and juvenile rearing would occur from proposed modifications at Coyote Valley Dam. Under baseline conditions, there is a potential for stranding juvenile salmonids when releases from the dam are ramped down for inspection and maintenance activities. Under the proposed project, inspection and maintenance activities would be timed to occur when Chinook salmon fry are not present in the river. Two pumps would be installed to provide a 25-cfs bypass flow when releases from the dam are shut down, and ramping rates would be reduced.

The most substantial negative effect to Chinook salmon is likely to occur from indirect habitat alterations resulting from bank stabilization (gravel-bar grading and vegetation maintenance) in the Upper Russian River mainstem. As primary spawning and rearing habitat occurs in the Upper Russian River, these activities could potentially affect all life-history stages of Chinook salmon, but the effects would be greatest for Chinook salmon rearing. Under the proposed project, protocols would be implemented to reduce the effect on rearing habitat. Under baseline conditions, extensive reaches in the river could potentially be affected by gravel-bar grading and vegetation maintenance. As discussed in previous sections, the extent of the work would be limited under the proposed project, and protocols would be implemented to protect salmonid habitat. Although habitat would be altered at sites worked on, the limitations under the proposed project are designed to ensure that sufficient, good-quality habitat remains in the mainstem to support the Chinook salmon population.

Instream habitat improvements planned in Dry Creek would improve conditions for fry and juvenile rearing by providing additional high-flow refuge areas and cover for rearing.

Chinook salmon also benefit from the fish passage project constructed at Mumford Dam, which now provides access to high-quality spawning and rearing habitat.

In summary, the most substantial negative project effects would occur from channel maintenance activities conducted in the Upper Russian River. However, these effects would be reduced over baseline conditions and protocols would be implemented to provide sufficient habitat for Chinook salmon rearing. These effects are offset slightly by beneficial effects that would occur from changes in the operation at Coyote Valley Dam (during annual inspections and maintenance), as well as habitat improvements in Dry Creek and other tributaries. Recent data from SCWA studies indicate that successful reproduction and rearing occur in the Russian River mainstem under baseline conditions, and reductions in negative effects under the proposed project would likely improve rearing-habitat conditions.

6.3.1.5 Downstream Migration

Although there would likely be direct effects to individual migrating juvenile fish, particularly in the Lower Russian River, implementation of the proposed project would reduce the risk from baseline conditions to a low level. There would not likely be substantial effects to habitat.

Among the most important components of the proposed project for Chinook salmon downstream migration are the improvements proposed at the Mirabel and Wohler diversion facilities. Under baseline conditions, there was a potential to entrain juvenile Chinook salmon in the infiltration ponds, both during the low-flow diversion season and during high-flow events that overtop the levees next to the ponds.

Fish screens at the Mirabel and Wohler diversion facilities would be upgraded to meet NOAA Fisheries criteria for fry and juveniles. Data from SCWA's Mirabel study indicate Chinook salmon in the Russian River emigrate through the Wohler Pool at about 90 mm FL (range 54-140 mm). NOAA Fisheries defines fry as less than 60 mm FL (NMFS 1996c). Therefore, juvenile-size fish are most likely to benefit.

The diversion structure and fish ladder on the west side of the inflatable dam would be integrated, and the fish screens would be upgraded to improve downstream fish passage. Implementation of a notched configuration in the inflatable dam during downstream migration periods would also facilitate downstream fish passage, although data from the monitoring program suggest Chinook downstream migration does not appear to be delayed in Wohler Pool or at the inflatable dam under baseline operations. Implementation of these measures would result in good fish passage conditions, with minimal to no delays, for Chinook salmon juveniles.

As discussed in the previous section, gravel-bar grading and vegetation removal activities carried out for streambank stabilization in the mainstem Russian River have the potential to affect juvenile Chinook salmon habitat. Under the proposed project, these activities would be much more limited, and protocols would be implemented to reduce effects to salmonid habitat. Furthermore, the effects to migration would be expected to be far less than for rearing.

In the Wohler/Mirabel area, direct effects to some individual fish may occur from gravel-bar grading that is done to increase infiltration rates. Implementation of protocols verified during the monitoring study at Mirabel is likely to reduce the risk to a low level. Inflation or deflation of the inflatable dam could potentially result in stranding of migrating fish. Juvenile fish could be entrained into the Mirabel or Wohler infiltration ponds for short periods of time during high-flow events or during the spring portion of the diversion season, but modifications to the fish screens and grading of the ponds would reduce the risk to a very low level. The risk to juvenile Chinook salmon is higher if they are entrained in the Riverfront Park during high-flow events, because they would be lost to the anadromous population. However, this would not happen frequently, so the risk to the population is low.

Juvenile Chinook salmon pass through the Estuary during outmigration from the Russian River. Since peak outmigration occurs during the early part of the year when the Estuary is still open to the ocean, effects on juvenile outmigration would generally not be expected. However, during *critically dry* years, low flows may result in spring sandbar closures. By eliminating artificial breaching, passage to the ocean may not be available as often as it may have been with artificial breaching conducted under baseline conditions. However, if habitat conditions in the lagoon are good, juvenile fish may benefit from additional rearing time in a food-rich environment that is likely to develop in the lagoon.

In summary, implementation of the proposed project would likely result in a net benefit to juvenile Chinook salmon migration due to improvements that would be made at Coyote Valley Dam and the Mirabel/Wohler diversion facilities. Structural and operational changes at Coyote Valley Dam (bypass flows and changes in ramping and scheduling of activities) would reduce or eliminate risks to rearing juvenile Chinook salmon in the Upper Russian River. Downstream passage of juvenile Chinook salmon would improve due to structural and operational changes of the Mirabel/Wohler diversion facilities, particularly from upgrades to the fish screens and grading of the infiltration ponds, and from a reduction in the rate of inflation of the inflatable dam. Implementation of protocols that limit effects of gravel-bar grading in the Mirabel and Wohler area would reduce direct effects to migrating Chinook salmon juveniles to a low level and improve conditions over baseline operations. Some minor benefits may occur from changes in the operation of the fish ladder and notching of the dam to facilitate downstream passage of smolts. Direct effects to some individual fish may occur during operation and maintenance activities, but cumulatively, the risk is likely to be low. Habitat alterations may occur from channel maintenance activities in the Upper Russian River, but they are not expected to have substantially negatively effects on migrating fish.

6.3.2 Chinook Salmon Response to the Proposed Project

The overall effects of the proposed project are summarized in Tables 6-5 and 6-6. In general, the proposed project would result in net benefits to Chinook salmon and their habitat. Some potential direct effects could result in injury or mortality of some individuals, particularly migrating adults and juveniles. Some of the channel maintenance actions also would negatively affect habitat, particularly in the Upper Russian River. Overall, under the proposed project, the conditions in the Russian River system would likely be beneficial to the continued survival of Chinook salmon in the river system, and would likely be improved over baseline conditions.

Among the most important benefits of the proposed project for Chinook salmon is eliminating the artificial breaching of the sandbar at the mouth of the Estuary during the summertime. By managing the Estuary as a closed system, upstream migration of Chinook salmon would often not begin until November, when the sandbar at the mouth of the Estuary is breached (either artificially or by rainfall). This would help ensure that returning spawners enter the Russian River when flows are more suitable for upstream migration, and should lead to an increase in the number of adults reaching spawning grounds throughout the mainstem and Dry Creek.

Table 6-5 Potential Project Benefits to Chinook Salmon

Life-History Stage	Project Benefits
All lifestages	Data from studies and monitoring are crucial to informed management decisions.
	Ecological and genetic risks to Chinook salmon would be eliminated with elimination of hatchery production. An integrated recovery program could be rapidly implemented if needed.
Adult migration	Elimination of summertime artificial sandbar breaching would help prevent premature entry of early spawners.
	Fish passage improvement projects would make tributary habitat available.
	Exit channel at Wohler infiltration ponds during high-flow season reduces risk of entrainment to very low level.
Juvenile rearing	Schedule dam inspection and maintenance activities when fry are not present. Reduce ramping rates at low flows and install pumps at Coyote Valley Dam to provide bypass flows.
	Instream habitat improvements in Dry Creek.
	With implementation of the Flow Proposal, rearing habitat in Dry Creek would be much better in dry years.
Juvenile migration	Improved fish screens at Mirabel and Wohler diversions.
	Exit channel at Wohler infiltration ponds during high-flow season reduces risk of entrainment to a very low level.
	Structural and operational improvements at Mirabel inflatable dam would improve fish passage.

Table 6-6 Potential Project Effects on Chinook Salmon

Life-History Stage	Low Continued Risks
Adult migration	Entrainment in Mirabel infiltration ponds.
	Entrainment in Riverfront Park lakes.
	Incidental harvest bycatch and hooking mortality from steelhead integrated harvest program.
Adult and juvenile migration, spawning and egg incubation	Localized habitat alterations from gravel-bar grading and vegetation removal in mainstem. (Proposed project would improve conditions over baseline.)
Juvenile rearing	Localized habitat alterations from gravel-bar grading and vegetation removal in Upper Russian River mainstem. Conditions would improve over baseline.
Juvenile migration	Gravel-bar grading in Mirabel and Wohler area.
	Inflation of the Mirabel inflatable dam may strand young fish.
	Entrainment and fish rescues in Mirabel and Wohler infiltration ponds.
	Entrainment in Riverfront Park lakes.

Other project activities that would improve upstream and downstream passage include improved fish screens at Mirabel and Wohler diversions, the exit channel at Wohler infiltration ponds, operational improvements at Mirabel inflatable dam, and instream restoration projects. These activities would have the same effect as reducing habitat fragmentation by making it easier for fish to access more of the Russian River watershed.

Data collected from ongoing field studies and monitoring activities also would benefit Chinook salmon. These studies would provide valuable information to support informed management decisions in recovery planning.

Cessation of hatchery production would help eliminate genetic and ecological risks associated with hatchery production. A proposed Chinook salmon supplementation recovery program could be rapidly implemented if future monitoring efforts indicate it is warranted. This program would collect wild returning adult Chinook salmon and use them as broodstock to build a naturally sustaining Chinook salmon population.

Finally, implementation of the Flow Proposal would improve rearing habitat in Dry Creek, particularly in *dry* years. In general the Flow Proposal is predicted to provide good to optimal flow conditions for rearing about 85 percent of the time in upper Dry Creek, which is almost twice as high as the current D1610 management scenario. Thus, rearing habitat for juvenile Chinook salmon in drought years should improve greatly compared to the baseline conditions.

Project operations that negatively affect primary rearing and migration habitat in the mainstem of the Russian River and Dry Creek are most likely to affect the Chinook salmon population. Habitat alterations could occur from channel maintenance activities in the mainstem of the Russian River, and this may affect habitat for juvenile fish in the Upper Russian River. However, protocols would be implemented to reduce effects over baseline conditions and would likely preserve sufficient rearing habitat. Direct effects to fish could also occur at the Mirabel and Wohler diversion facilities and at the Riverfront Park.

The proposed project would reduce a number of effects under baseline conditions to a low or negligible level, and would likely result in a net benefit to Chinook salmon. Beneficial effects are likely to accrue to juvenile rearing and downstream migration through structural and operational modifications at Coyote Valley Dam and at the Mirabel and Wohler diversion facilities. Furthermore, implementation of the Flow Proposal would enable implementation of the Estuary management proposal, which could help protect early Chinook spawners. Revised protocols for channel maintenance in the Upper Russian River would reduce effects to habitat relative to baseline conditions.

Although effects to individual fish and Chinook habitat would likely occur, there would likely be a net benefit to the Chinook salmon population with implementation of the proposed project.

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7.1 INTERRELATED/INTERDEPENDENT ACTIVITIES

This section identifies the interrelated or interdependent activities associated with the proposed project described in Section 4.0. In a Section 7 consultation, the interrelated and interdependent activities are considered in concert with proposed project to determine project-related effects. The effects analysis for the interrelated and interdependent activities consider direct effects on listed species and critical habitat. The effects analysis should include an assessment of factors that would reduce the likelihood of the survival of listed salmonids or prevent their recovery (NMFS 1999b).

The ESA Section 7 handbook defines an *interrelated activity* as an activity that is part of the proposed action and depends on the proposed action for its justification. In other words the activity would not occur if it were not for the existence of the proposed action under consultation. An *interdependent activity* is defined as an activity that has no independent utility (or function) apart from the action under consultation.

An effective way to determine whether other activities are interrelated to, or interdependent with, the proposed project is to apply the "but for" test (USFWS and NMFS 1998). To test if an activity is *interrelated*/*interdependent*, the relevant inquiry is whether another activity would occur <u>but</u> <u>for</u> the proposed project under consultation. If it would not occur, <u>but</u> <u>for</u> the proposed project, then the activity is interrelated or interdependent and its effect on listed species must be assessed as part of the overall project. If the activity in question would occur "regardless" of the proposed project under consultation, then the activity is not interdependent or interrelated.

Interrelated and interdependent activities are always measured against the project. For example, the USACE could request a consultation on the construction of a dam, which would provide water to private irrigation canals once the dam is built. Since the private irrigation canals would not exist "but for" the presence of the constructed dam, they are interrelated to the proposed project. In this example, the effects of the activity external to the project (the canals) are analyzed with the effects of the action under consultation (the dam) because it is interrelated to the proposed action.

The following activities are interrelated to, or interdependent with, the proposed project:

- Water transmission to the water contractors and the wastewater discharge, recycling, water conservation measures, and runoff into streams of transmitted water.
- Non-native predators stocked in reservoirs for recreational fishing.
- Recreational fishing for steelhead.

- Channel maintenance on Public Law (PL) 84-99 (nonfederal) sites in Russian River and Dry Creek.

- City of Ukiah's Hydroelectric Facility.

Section 7 of the Endangered Species Act requires that the effects of the project under consultation must be analyzed together with the effects of any interrelated/interdependent activities, to determine the overall impact of the project on listed salmonids. In sections 7.2 through 7.6, the effects of each interrelated/interdependent activity are individually discussed. In Section 7.7, the total effects of the proposed project and the interdependent/interrelated activities on salmon species in the Russian River are analyzed. In Section 7.8 the cumulative effects of future activities in the Russian River Basin are described. Finally, Section 7.9 provides a brief summary of all of these activities and their effects on listed salmonids.

7.2 WATER TRANSMISSION TO THE SERVICE AREAS OF THE WATER CONTRACTORS

SCWA is a water wholesaler that provides water to water contractors that serve approximately 600,000 people in Sonoma and Marin counties (SCWA 2000c). SCWA operates a water transmission system that delivers water to public and investor-owned water distribution systems operated by municipal water customers. The water transmission system is financed by payments under the Eleventh Amendment Agreement (see Section 3.3.1). The parties to the agreement are SCWA, the cities of Santa Rosa, Petaluma, Rohnert Park, Sonoma, and Cotati, the North Marin Water District (NMWD), Valley of the Moon Water District, and Forestville Water District. In this document, these parties are referred to as the primary water contractors. SCWA also supplies water to the Marin Municipal Water District through separate contracts (S. Shupe, Sonoma County, pers. comm. 2003). There are also several smaller water users (referred to as secondary contractors) who obtained water directly from SCWA's transmission system and/or divert water from the Russian River under SCWA's diversion rights.

7.2.1 WATER DISTRIBUTION

The principal sources of water for the SCWA water transmission system are Dry Creek and the Russian River. The flows in these streams are regulated with releases from Lake Mendocino and Lake Sonoma via the Coyote Valley and Warm Springs dams (see Sections 3.1 and 3.2). A secondary source of water for SCWA is its three production wells located west of the City of Santa Rosa, near the Laguna de Santa Rosa (SCWA 2000c).

7.2.1.1 Primary Water Contractors

Figure 7-1 is a general map showing the location of SCWA's water transmission system and the primary water contractors' service area. The service areas extend from Marin

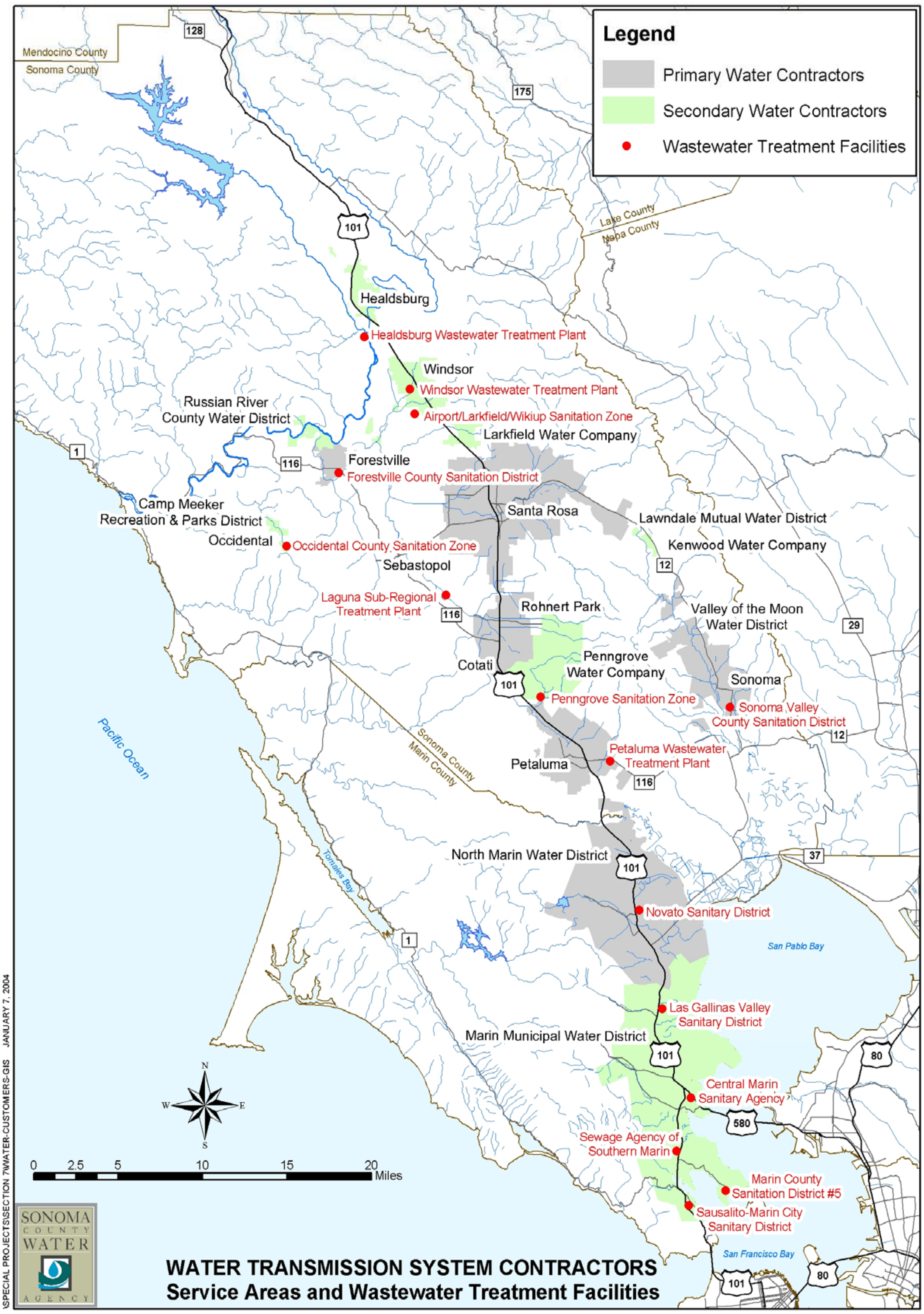

Figure 7-1 Service Areas of SCWA's Water Contractors

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County northward to Santa Rosa, and to the City of Sonoma on the east and to Forestville on the west. Table 7-1 shows the water distribution infrastructure for the eight water contractors. For most contractors, SCWA provides the primary water supply, while a few contractors, such as Rohnert Park, get a significant amount of water from local wells.

The eight primary water contractors receive about 85 percent of the total amount of potable water delivered by SCWA annually (Table 4-1 in SCWA 2000c). A brief description of the water distribution facilities of these primary contractors is given below:

- The City of Santa Rosa depends almost entirely upon SCWA for its water supply. Santa Rosa's water distribution system includes 554 miles of pipelines, 18 enclosed reservoirs that store 18.2 million gallons (MG), and 16 pump stations to supply the city's 160,000 customers. The city also operates seven wells, which provide a backup water supply of 6.5 MG of water per day (mgd) (SCWA 2000c).

  Santa Rosa's rate of delivery during the peak demand month is limited to 56.6 mgd and annual deliveries are limited to 29,100 acre feet (AF). The city's current average-day peak-month demand for water usage is 34.9 mgd (SCWA 2000c).

- The City of Rohnert Park depends upon groundwater and water supplied by SCWA to meet the demands of its 40,000 residents. Rohnert Park's maximum average monthly delivery rate is limited to 15.0 mgd, and an annual limit of 7,500 AF.

  The principle source of water for Rohnert Park is a series of 39 groundwater wells, which account for approximately 61 percent of the city's water supply (with the remaining 39 percent received from SCWA). These wells have a reliable capacity of 4,481 AFY. In addition, the city has seven storage reservoirs with 4.2 MG of storage capacity (SCWA 2000c).

- The City of Sonoma's maximum average monthly delivery rate is limited to 6.3 mgd, with an annual limit of 3,000 AF. The city currently has 3 operational groundwater wells with a production capacity of 1.1 mgd and a long-term reliable capacity of approximately 448 acre feet per year (AFY) (SCWA 2000c).

- The City of Cotati obtains approximately 70 percent of its water from SCWA. The city obtains the rest of its water from 3 operational groundwater wells with a production capacity of 1.1 mgd. The long-term reliable capacity of these wells is approximately 896 AFY.

  Cotati's maximum average monthly delivery rate is limited to 3.8 mgd, with an annual limit of 1,520 AF (SCWA 2000c).

- The Community of Forestville receives all of its water from SCWA. Under the current contract, Forestville is limited to a maximum average monthly delivery rate of 1.5 mgd. In 2000, Forestville received approximately 480 AF of water from SCWA. There is no annual limit on water supplied by SCWA to the Community (SCWA 2000c).

Table 7-1 Primary Water Contractors

Water Contractor	Customer Connections	Pumping Stations	Storage Tanks	Storage Capacity (MG)	Wells	Local Production Capacity (AFY)	Maximum Average Monthly Delivery Rate (mgd)	Annual Delivery Limit (AF)	Nonagricultural Water Use[1]
Santa Rosa	46,060	16	18	18.2	7 standby use	4,817	56.6	29,100	RES: 71% IIC: 12% LS: 17%
Rohnert Park	8,496	0	7	4.2	39	4,481	15.0	7,500	NA[2]
Sonoma	3,550	-	5	3.2	3	448	6.3	3,000	RES: 75% IIC: 19% LS: 6 %
Cotati	7,760	-	2	1.1	3	896	3.8	1,520	NA
Forestville	913	-	4	1.7		0.0	1.5	No annual limit	RES: 73% IIC: 23% LS: 4 %
Petaluma	17,940	7	11		11	3,585	21.8	13,400	RES[3]: 69% IIC: 31% LS: NA
NMWD	21,300	-	26	27.5	0	2,000	19.9	14.100	RES: 80% IIC: 18% LS: 2%
Valley of the Moon	6,648	-	9	4.5	5	1,008	8.5	3,200	RES[3]: 85% IIC: 15% LS: NA

[1] Nonagricultural Water Use: RES (residential), IIC (industrial/institutional/commercial), LS (landscaping).
[2] NA: Not Available.
[3] Percentages calculated using only RES and IIC water use values.
Source: SCWA 2000c

- The City of Petaluma obtains its water supply from 11 operational groundwater wells and SCWA. The groundwater wells have a production capacity of 5.4 mgd.

  Petaluma's maximum average monthly delivery rate is limited to 21.8 mgd, with an annual limit of 13,400 AF. The city's 11 operational groundwater wells have a long-term reliable capacity of 3,585 AFY (SCWA 2000c).

- NMWD supplies water to customers in the City of Novato, as well as in several unincorporated towns in northern Marin County (e.g., Point Reyes Station, Bear Valley, Inverness Park, and Olema). In 2000, NMWD supplied 10,736 AF of water to 21,300 households in its service area (SCWA 2000c).

  NMWD is limited to a maximum average monthly delivery rate of 19.9 mgd from SCWA, with an annual limit of 14,100 AF. Due to its distance from SCWA storage facilities, NMWD maintains 26 storage tanks in service, capable of storing a total of 27.5 MG of water. NMWD also has a local surface water source from Lake Stafford, which has a safe yield of approximately 2,000 AFY (SCWA 2000c).

- The Valley of the Moon Water District (VOMWD) serves about 6,000 households in the Sonoma Valley. It receives 85 percent of its water supply from SCWA, with the remainder from local wells.

  VOMWD's maximum average monthly delivery rate is limited to 8.5 mgd, with an annual limit of 3,200 AF. VOMWD currently has 5 operational groundwater wells with a total long-term reliable capacity of approximately 1,008 AFY (SCWA 2000c).

7.2.1.2 Secondary Water Contractors

SCWA also supplies water to other water districts, municipalities, and private water companies to supplement local water needs. The largest of these secondary water contractors is the Marin Municipal Water District (MMWD), which accounts for 88 percent of SCWA's water that is not delivered to the primary contractors. Other smaller contractors include the Town of Windsor, California-American Water Company (Larkfield District), the Penngrove Water Company, the Lawndale Mutual Water Company, and the Kenwood Water Company. Finally, the Russian River County Water District, diverts water from the Russian River under SCWA's water rights, while the Camp Meeker Recreation and Parks District, the City of Healdsburg, and the Occidental Community Service District are waiting for RWQCB approval to divert water under SCWA's water rights. A brief description of these facilities is given below:

- MMWD supplies water to approximately 185,000 people in a 147-square-mile area of Marin County, California, located just across the Golden Gate Bridge from San Francisco. The MMWD gets approximately 75 percent of its water supply from five reservoirs located on Mt. Tamalpais (built between 1905 and 1948) and two reservoirs in west Marin County. The remaining 25 percent of MMWD's water supply is delivered via the SCWA transmission system in Sonoma County and pipelines operated by NMWD and MMWD in Marin County (Marin Municipal Water District 2003).

SCWA supplies MMWD with approximately 8,000 AFY, however, the amount of water can go higher depending on demand (S. Shupe, Sonoma County, pers. comm. 2003). The maximum rate of water delivery from the SCWA Transmission System to MMWD during May through October is 12.8 mgd (Nelson 2001).

- The Town of Windsor obtains its water supply primarily from three large wells located in the deep gravel strata adjacent to the Russian River and one standby well located in the center of town (Santa Rosa 2003). Windsor has a direct connection to the SCWA aqueduct, which can be used during peak periods to augment water supplies. The town received approximately 370 AF of water from SCWA in 2000-2001 (Nelson 2001). Between 1999 and 2003, Windsor also diverted an average of 3,589 AF of water annually from the Russian River under SCWA's water rights (C. Murray, SCWA, pers. comm. 2003).

- The Larkfield District of the California American Water Company supplies water to residents in the unincorporated communities of Wikiup and Larkfield. The water company receives approximately 450 AF of water per year from the SCWA Transmission System (Nelson 2001).

- The Penngrove Water Company supplies water to residents in the unincorporated community of Penngrove. The water company receives approximately 190 AF of water per year from the SCWA Transmission System (Nelson 2001).

- The Lawndale Mutual Water Company receives approximately 60 AF of water per year from the SCWA Transmission System (Nelson 2001).

- The Kenwood Village Water Company supplies water to 500 year-round residents in an unincorporated area of Kenwood Village. The Company receives approximately 3.7 AF of its annual water supply from SCWA (Nelson 2001).

- The Russian River County Water District (RRCWD) supplies water to over 1,180 residents. The RRCWD diverted 47 AF of water from the Russian River under SCWA's water rights in 1999, but has not diverted any water under SCWA's water rights in the past 3 years (C. Murray, SCWA, pers. comm. 2003).

- Camp Meeker Recreation and Parks District (CMRPD) supplies water to 350 year-round residents. The CMRPD has an agreement with SCWA to divert 90 AF under SCWA's water rights (C. Murray, SCWA, pers. comm. 2003). The City of Healdsburg has an agreement with SCWA to divert 4,400 AF under SCWA's water rights (C. Murray, SCWA, pers. comm. 2003). The Occidental Community Services District has an agreement with SCWA to divert 65 AF under SCWA's water rights (C. Murray, SCWA, pers. comm. 2003).

7.2.1.3 Operational Best Management Practices

The water contractors deliver water to their customers through their own pipeline systems that connect to the SCWA transmission system. They also use groundwater from wells to supplement the water they receive from SCWA, and storage tanks to provide water storage for emergencies and to help meet peak demand during maximum demand periods.

Substances used to treat water include chlorine, an orthopolyphosphate compound, and caustic soda (sodium hydroxide). Each substance is contained in accordance with strict regulations, and would not be released under normal conditions. Any significant risk to listed species would be due to accidental spills. The risk of an accidental spills and subsequent exposure of fish to treat water are minimized by up-to-date Spill Prevention, Containment, and Control (SPCC) plans.

The water contractors generally follow the same operational BMPs that SCWA employs, to ensure that potable water does not contaminate local tributaries. Below is a general description of these practices. Note that there may be variations in operations among the different water contractors, due to differences in size and complexity of their systems.

- Groundwater Wells: Operation of wells frequently requires discharging well water to surface drainages for sampling or flushing purposes. These discharges usually involve unchlorinated water, although minor discharges of chlorinated water may be necessary for sampling purposes. This sampling is done to determine if water quality is in compliance with potable water regulations.

  Well maintenance operations generally involve small quantities of potable unchlorinated water; thus, any runoff into the Russian River should not affect water quality.

- Water Storage Tanks: Maintenance of the water storage tanks requires that the tanks be emptied every few years to allow for re-coating of interior surfaces to prevent leaching of metals. These discharges occur under controlled conditions after obtaining permission from the California Department of Health Services (CDHS) and the NCRWQCB (ENTRIX, Inc. 2001d).

  A portion of the water is released to constructed drainage ditches (typically riprapped) to dissipate the energy of discharge flows in order to reduce the potential for erosion. Maintenance staff will add a dechlorinating chemical to any discharge to eliminate any chlorine residue in the discharge. Discharges into constructed ditches are allowed to flow into Russian River tributaries (e.g., Laguna de Santa Rosa, and Atascadero Creek).

  In general, normal operation and maintenance activities are performed with trained personnel and are guided by permitting regulations. Because chlorine would be in the form of a gas, if spilled, the likelihood of it entering the water in severe concentrations is limited. A catastrophic spill in the water from storage tanks could have severe on salmonids within the area of the spill. The SPCC plans (see Section 5.2.5), however, dramatically reduce the chance of spill. Thus, normal operations do not appear to present a significant risk to listed salmonids in the area of the storage tanks.

- Transmission Pipelines: Valves are installed on pipelines to relieve pressure surges, and to prevent breakage. Pressure surges generally occur when power outages trigger a sudden shutdown in water pumps, main vales are open or closed too quickly, or there are sudden pressure losses in gravity feed systems. Pressure surges are generally infrequent, but can result in the discharge of treated potable water.

  Many water contractors routinely flush mains to help prevent stagnated water and eliminate sedimentation that has accumulated in the water mains. A total flush of the system is usually performed at least once a year and discharged water is typically monitored for chlorine residual and clarity.

  Pressure surges, flushing, and accidental spills from the transmission pipelines of the water contractors have the potential to introduce chlorinated water into streams in the Russian River watershed. Most contractors have added dechlorination baskets and to valves to reduce the effects of spillage should they fail. Chlorine can also be removed from potable water during main flushing using diffusers that hold thiosufate tablets.

7.2.1.4 Effects of Water Distribution on Listed Salmonids

Water distribution systems effects are usually related to the use and storage of chemical compounds and other hazardous materials in the water systems. Any risk to listed salmonids would be due to accidental point discharge of treated water containing trace concentrations of these chemicals. Substances used to treat potable water include chlorine, an orthopolyphosphate compound, and caustic soda (sodium hydroxide).

The risk of accidental spills and subsequent exposure of fish to treated water are minimized by the water contractors' SPCC plans and other precautions listed above. Should a spill of potable water containing chlorine or other chemicals occur, the effects on salmonids are likely to be limited to a small area. There are several factors that influence the magnitude of the effects associated with a spill event. The primary factors include the residual chlorine or caustic soda concentration in the discharged water, the capacity of the receiving water to consume or dissipate the residual chemical concentration via physical or biological reactions, and the duration of the spill event. In instances where the chemical concentration is actually high enough to adversely effect salmonids, the effect on individual fish will depend on their ability to detect and move away from the point of discharge.

The operational BMPs implemented by the water contractors to minimize losses of valuable treated water and minimize the cost associated with water treatment help protect water quality in the service area. These practices and the limited number of potential discharge points in the distribution system immediately adjacent to sensitive salmonid habitat, limits the potential for trace amounts of chlorine (added as a disinfectant) and caustic soda (added for corrosion control) to be discharged into spawning and rearing habitat. These institutional controls, along with the physical processes noted above, reduce the risks to salmonids in the Russian River associated with the *interrelated activity* of distributing SCWA water to the water contractors.

7.2.2 Wastewater and Recycled Water

After water purchased by the water contractors is used by their customers, it is collected in underground sewage systems and pumped to one of several wastewater treatment plants (WWTPs) in SCWA's service area, where it receives either secondary or tertiary treatment. Many of these plants also treat water from non-SCWA sources (S. Shupe, Sonoma County, pers. comm. 2003).

The disposal method of treated effluent from the WWTPs varies by season. In general, wastewater may only be discharged into streams between mid-fall and mid-spring of each year. During the remainder of the year, treated wastewater is recycled for irrigation. Water purchased from SCWA that is not recycled is usually discharged back into the Russian River or into the San Francisco Bay only during the discharge season. Wastewater not used for irrigation or habitat enhancement during other times of the year is stored in storage tanks.

The North Coast Regional Water Quality Control Board (NCRWQCB) and the San Francisco Bay Regional Water Quality Control Board (SFBRWQCB) regulate treatment plant discharges in SCWA's service area (depending on location) and impose waste discharge requirements.

The Water Quality Control Plan for the North Coast has established policies and an implementation schedule for controlling wastewater discharges to the Russian River (NCRWQCB 1993b). These policies cover discharges of domestic and industrial sewage, nonhazardous wastes from dewatering activities, contaminated groundwater, nonhazardous manufacturing process wastes, and stormwater runoff. In terms of wastewater regulations, discharges from treatment plants into streams are not allowed to exceed 1 percent of the receiving flow. The City of Santa Rosa's sewage treatment plant has an exception, specified in Resolution No. 89-111, that allows discharge rates as high as 5 percent of the flow rate of the Russian River during the discharge period when approved by the NCRWQCB's Regional Board's Executive Officer (NCRWQCB 2002b).

Wastewater discharged to the San Francisco Bay region is governed by policies of the SFBRWQCB. These policies stipulate that treatment plants are prohibited from discharging wastewater into any waterway without first being diluted by a factor of 10:1. They also prohibit the release of treated discharge into dead-end sloughs and similar confined waters, and require that all effluent must be monitored for toxins and solid waste material (SFBRWQCB 2001).

7.2.2.1 Wastewater Treatment Plants

Eleven wastewater treatment plants (WWTPs) serve SCWA's primary and secondary water contractors, including contractors who divert water under SCWA's water rights. Three of the plants are operated and maintained under contract by SCWA and are located in Forestville, Larkfield-Wikiup, and Southern Sonoma Valley. SCWA is also under contract to operate and maintain a WWTP owned by the Occidental County Sanitation District in West Sonoma County. The remaining plants are located in Santa Rosa, Petaluma, Novato, Windsor, and Healdsburg.

These facilities are operated using standard BMPs and are covered by SPCC plans and emergency operations plans that outline safe operating protocols. The emergency plans provide procedures to avoid and respond to accidental spills and releases of hazardous substances (SCWA 1998c).

The locations of the WWTPs are shown in Table 7-2, along with the treatment capacities of the plants, the disposal methods of treated effluent, and the streams where treated water is discharged during the winter months (SCWA 2000c).

Below is a brief description of each treatment facility:

- The Sonoma Valley County Sanitation District (SVCSD) is located on East 8th Street near the City of Sonoma and has a wastewater collection system serving an area over 4,500 acres. The facility services approximately 16,000 single-family dwellings. Wastewater from these dwellings is collected in sanitary sewer pipelines and transported to the Sonoma Valley County Sanitation District plant, which is being to refitted with a membrane system to treat wastewater to a tertiary standard by 2004 (J. Jaspers, SCWA, pers. comm. 2003).

  The treatment plant has an average dry weather flow design capacity of 3.0 mgd and can treat up to 8.0 mgd during the wet weather flow period. During 2000 and 2001, the plant had average dry weather flow (ADWF) of 2.8 and 2.5 mgd, respectively (SCWA 2000c).

  Between November 1 and April 30, treated wastewater is discharged into Schell Slough, a tributary to San Pablo Bay. Schell Slough is a tidal estuary, which receives freshwater from Schell Creek during the wet weather months (mid-fall to mid-spring). During the rest of the year, Schell Slough is a dead-end slough and is flushed only by limited tidal action (SFBRWQCB 2002).

  Discharge of wastewater by SVCSD to Schell Slough can not exceed an initial dilution of 1 part treated water to 10 parts estuarine water to ensure that water quality objectives for the estuary are meet. In general, the effluent limitations specified under the NDPES permit for discharges to San Pablo Bay tributaries are based on the minimal tolerances of aquatic organisms to increases in metal concentrations and changes in salinity (SFBRWQCB 2002).

Table 7-2 Wastewater Treatment Plants Serving the Water Contractors

Area	Wastewater Agency	No. Plants	ADWF[1] Capacity (mgd)	Treatment Level	Method of Disposal	Discharge Channel
Sonoma, Valley of the Moon	Sonoma Valley County Sanitation District	1	3.0	Tertiary[2]	Ag. Land (summer) Slough (winter)	Schell Slough, a Tributary to San Pablo Bay
Forestville, Mirabel Heights	Forestville County Sanitation District	1	0.1	Tertiary[2]	Ag. Land (summer) Creek (winter)	Jones Creek, a Tributary to the Russian River
Occidental	Occidental County Sanitation District	1	0.05	Secondary	Ag. Land (summer) River (winter)	Dutch Bill Creek, a Tributary to the Russian River
Santa Rosa, Rohnert Park, Cotati, Sebastopol	Santa Rosa Subregional Wastewater Reclamation System	2	19.2	Tertiary	Ag. Land Geysers Project (summer) River (winter)	Laguna de Santa Rosa
Petaluma, Penngrove	City of Petaluma WWTP	1	5.2	Secondary	Ag. Land (summer) Creek (winter)	Petaluma River (S.F. Bay region)
NMWD	Novato Sanitary District	2	4.5 2.0	Secondary Tertiary	Ag. Land (summer) Bay (winter)	San Francisco Bay
Town of Windsor	Town of Windsor WWTP	1	2.8	Tertiary	Ag. Land (summer) Creek (winter)	Mark West Creek
Wikiup and Larkfield	Airport-Larkfield-Wikiup Sanitation Zone	1	0.9	Tertiary	Ag. Land (summer) Storage (winter)	No Stream Discharge
City of Healdsburg	Healdsburg WWTP	1	NA	Secondary	Percolation Ponds	No Stream Discharge

[1] ADWF = average dry weather flow, NA = not available
[2] In the process of constructing tertiary treatment facilities
Sources: SCWA 2000c; P. Jeane, SCWA, pers. comm, December 12, 2003.

- The Forestville County Sanitation District will provide tertiary wastewater treatment for the unincorporated communities of Forestville and Mirabel Heights by 2004. The design capacity of the treatment plant is 0.1 mgd and the average dry weather flow to the treatment plant is approximately 0.063 mgd.

  From November to May of each year, treated wastewater from the Forestville plant is discharged into Jones Creek, a tributary of Green Valley Creek, at a rate of up to 1 percent of the receiving flow. During other times of the year, effluent from the plant is used to irrigate agricultural lands. Approximately 11 AFY is reused to irrigate between 25 to 30 acres of land (SCWA 2000c).

- The Occidental County Sanitation District (OCSD) owns a municipal wastewater treatment facility, located east of the community of Occidental, which is operated and maintained under a contract with SCWA. The WWTP treats water to a secondary standard and has a maximum design capacity of 0.05 mgd.

  Between October 1 and May 14, treated wastewater from OCSD is discharged into Dutch Bill Creek, a tributary of to the Russian River, at a rate of up to 1 percent of the receiving flow (SCWA 2003b). The Santa Rosa Subregional Wastewater Reclamation System (SRSWRS) is comprised of the Laguna and Oakmont wastewater treatment plants. These facilities provide tertiary wastewater treatment for the cities of Santa Rosa, Rohnert Park, Sebastopol, Cotati, and the South Park County Sanitation District.

  The Laguna WWTP has an ADWF treatment capacity of 19.2 mgd and an average dry weather inflow of approximately 17.5 mgd. The plant has the capacity to store up 5,100 AF of recycled water, providing up to three months of storage at current flows. The Oakmont WWTP has a treatment capacity of 0.7 mgd and an average dry weather flow of 0.5 mgd. It is operated during the irrigation season and is shut down during the winter (when wastewater is sent to the Laguna WWTP only).

  Recycled water that is not stored or directly conveyed for irrigation is discharged to the Laguna de Santa Rosa between October 1 and May 14, in compliance with the permit from the NCRWQCB. The treatment plant has an exception, specified in Resolution No. 89-111, that allows discharge rates as high as 5 percent of the flow rate of the Russian River during the discharge period when approved by the NCRWQCB. Treated water may be discharged to the Laguna de Santa Rosa or Santa Rosa Creek from several points, primarily at Meadowland pond and Delta pond. The volume and frequency of discharge at any given location varies due to operational and seasonal considerations, including irrigation needs, storage levels, and weather (SCWA 2000c).

  The SRSWRS has begun distributing reclaimed water through the Geysers Project pipeline system. The project will transport 11 mgd of tertiary-treated recycled water to the Geysers steam fields, where it will be used to generate electricity. The project will make additional water available for future agricultural irrigation in the Alexander Valley (a premium grape-growing region) and other portions of the county. The first 30 miles of the Geyser pipeline have been oversized and could eventually accommodate wastewater flows of more than 40 mgd. The project is expected to reduce by 60 percent the amount of wastewater annually discharged into the Russian River by SRSWRS. The project will also provide expanded long-term water reuse opportunities for the Subregional System, as well as future reuse opportunities for other agencies such as Windsor, Healdsburg, and the County of Sonoma (Santa Rosa 2003b).

- The City of Petaluma Wastewater Treatment Facility provides wastewater treatment for the City of Petaluma and also treats water that is collected by the Penngrove Sanitation Zone. The Petaluma plant uses biofiltration, active sludge, and aeration ponds to meet secondary treatment standards. The design capacity of the Petaluma facility is 5.2 mgd and the current average daily dry-weather flow is approximately 4.6 mgd (SCWA 2000c).

  The Wastewater Treatment Facility is allowed to discharge treated wastewater to the Petaluma River between October 21 and April 30. Wastewater must first be diluted by a factor of 10:1 before it can be discharged into the river. Discharge of wastewater into dead-end sloughs and similar confined waters is prohibited (SFBRWQCB 1998).

- The Novato Sanitary District operates two WWTPs, Ignacio Publicly Owned Treatment Works (IPOTW) and Novato Publicly Owned Treatment Works (NPOTW), that serve Novato and surrounding areas in North Marin County. The IPOTW treats water to a tertiary standard and has a maximum design capacity of 2.0 mgd. The NPOTW treats water to a secondary standard and has a maximum design capacity of 4.5 mgd.

  Novato Sanitary District is allowed to discharge treated water to San Francisco Bay via a shallow water outlet between September 1 and May 31. The plant is prohibited from discharging wastewater from any point where it does not receive a minimum initial dilution of 10:1, or into dead-end sloughs and similar confined waters (SFBRWQCB 1999).

- The Town of Windsor WWTP is located on Windsor Road, approximately 8 miles north of Santa Rosa and 5 miles south of Healdsburg. The treatment plant treats wastewater to a tertiary standard (P. Jeane, SCWA, pers. comm. 2003) and has an average dry weather flow of 2.25 mgd and a peak weekly wet weather flow capacity of 7.2 mgd (NCRWQCB 2002b).

  Wastewater from Windsor is collected in 70 miles of sanitary sewer pipelines and transported to the WWTP for tertiary treatment. Following treatment, water is pumped through an irrigation/discharge transmission main, which runs approximately 5 miles from the effluent pump station to the Mark West Creek. It is used for discharges to Mark West Creek and for irrigation on nearby lands. The

WWTP is permitted to discharge treated effluent at a rate of up to 1 percent of the flow of the receiving water between October 1 and May 14 (NCRWQCB 2002b).

- Airport-Larkfield-Wikiup Sanitation Zone serves the unincorporated communities of Wikiup and Larkfield. The treatment plant has a design capacity of 0.9 mgd average dry weather flow (NCRWQCB 2001c), and treats wastewater to tertiary standard using a membrane system (P. Jeane, SCWA, pers. comm. 2003). All of the treated wastewater from this facility is recycled for use in irrigation.

- The City of Healdsburg's wastewater treatment system consists of 36 miles of sewer mains and nine sewer lift stations. The plant treats wastewater to secondary level and the effluent is discharged into a percolation pond where it can evaporate and/or percolate. Under its current permit, the City of Healdsburg WWTP is not allowed to discharge effluent into the Russian River.

7.2.2.2 Recycling of Treated Wastewater by the Water Contractors

To reduce water usage and to fulfill the requirement of NPDES restrictions on discharge of treated water into streams, the water contractors have implemented a variety of water recycling programs. These programs use reclaimed treated effluent from WWTPs to increase water availability for agriculture, parks, urban landscaping, and golf courses. Some of the recycling programs that are currently in use or that are under consideration are listed below.

Santa Rosa Subregional Wastewater Reclamation System

The City of Santa Rosa operates and maintains the Santa Rosa Subregional Wastewater Reclamation System, which treats wastewater for the cities of Cotati, Rohnert Park, Sebastopol, Sonoma, and Santa Rosa, as well as the unincorporated South Park County Sanitation District. It is composed of the Laguna and Oakmont Wastewater Treatment Plants, which provide tertiary wastewater treatment for the cities of Cotati, Rohnert Park, Santa Rosa, Sebastopol, and the South Park County Sanitation District.

Reclaimed water from the Subregional System is used to irrigate golf courses, and commercial properties in Santa Rosa and Rohnert Park, and agricultural areas (including vineyards) in the vicinity of Santa Rosa, Rohnert Park, Cotati, and Sebastopol. Approximately 10,000 AF of recycled water is used to irrigate 6,000 acres of land during the summer. Storage of treated wastewater increases in the fall after the irrigation season ends. Under NCRWQCB guidelines, tertiary treated water can be discharged to the Laguna de Santa Rosa between October 1 and May 15, only after the flows at the Hacienda Bridge (near Guerneville) exceed 1,000 cfs (SCWA 2000c). Discharge cannot exceed 1 percent of the Russian River flow except upon written authorization from the Executive Director when up to 5 percent discharge can be permitted.

The Santa Rosa Subregional Wastewater Reclamation System plans to increase the amount of reclaimed water it recycles through the proposed Geysers Recharge Project. The project would transport 4,000 MG of recycled water per year to the Geysers steamfield for the generation of electricity. The Geysers Project will allow the Subregional System to operate independently of weather conditions and relieve the potential for discharges exceeding permitted amounts into the Laguna de Santa Rosa.

City of Petaluma

The SFBRWQCB only allows the Petaluma WWTP to discharge effluent into the Petaluma River between November 1 and April 30. Therefore, in the summer, the City of Petaluma recycles approximately 36 percent of its annual dry weather flow of waste-water, which receives secondary treatment prior to recycling. The treated recycled water is then used to irrigate 800 acres of agriculture and 100 acres of golf course in the vicinity of the city. In 1999, the Petaluma Facility recycled approximately 2,393 AF of treated effluent between May and October (SCWA 2000c).

The City of Petaluma is in the process of developing a new wastewater treatment plant that will produce additional recycled water to serve the community. The facility will serve the existing service area by providing tertiary treatment and helping reduce usage of Russian River water (SCWA 2000c).

To further reduce its water use, Petaluma has begun implementing a comprehensive monitoring, operations, and maintenance program for the city's 200 miles of water collection pipeline to identify leaks and prioritize needed repairs.

Forestville County Sanitation District

The NCRWQCB only allows the Forestville County Sanitation District to discharge wastewater to Jones Creek (a secondary tributary to the Russian River) from November to May. While the district currently treats wastewater to a secondary level, they are in the process of upgrading their facility to allow for tertiary treatment. During the rest of the year, recycled effluent from the Forestville treatment plant is used to irrigate vineyards, berry farms, and pastures in the Forestville area. Approximately 11 MG of water per year is reused to irrigate between 25 and 30 acres. The Forestville to Graton pipeline allows for the delivery of recycled water to property owners along the pipeline route (SCWA 2003b).

Novato Sanitary District

Between November and April, the SFBRWQCB permits the Novato Sanitary District to discharge treated wastewater to the San Francisco Bay, via a shallow water outlet. During the rest of the year, the discharge of effluent is prohibited to the Bay and the Novato Sanitary District stores treated wastewater in two storage ponds. Water stored in the ponds is used for wildlife habitat and the irrigation of 820 acres of agricultural land adjacent to Highway 37. Approximately 1,850 AF of reclaimed water is recycled annually from the two treatment facilities (IPOTW and NPOTW).

City of Sonoma and Valley of the Moon Water District

Between May 1 and October 31 water treated at the SVCSD wastewater facility is transported to their reclamation facility where it is used for wetland enhancement and to irrigate pastures and vineyard land. Effluent is currently treated to a secondary level, however, the district is planning on upgrading to tertiary treatment in 2004. Approximately 1,200 AF of effluent is reused on an annual basis (SCWA 2003b). The reclamation facility includes four water storage reservoirs that supply irrigation water to local water users (SFBRWQCB 2002).

The reclamation project also includes three wetland enhancement areas and eleven upland ponds located approximately three miles southeast of Schell Slough. The upland ponds provide open water habitat for waterfowl. The enhancement project used treated wastewater to restore wildlife and wetland habitats, which had been previously modified through agricultural use to predominantly pasture and hay fields (SFBRWQCB 2002).

Between November 1 and April 30 treated wastewater at SVCSD is discharged into Schell Slough, a tributary to San Pablo Bay.

Town of Windsor

The Town of Windsor recycles about 300 MG of treated wastewater annually. Primary uses for reclaimed water are agricultural irrigation (food crops, vineyards, sod farms, Christmas tree farms, etc.), ornamental plants, parks and playing fields, golf courses, cemeteries, recreational waterways for boating and swimming, cooling tower water, groundwater recharge, and toilet flushing (Town of Windsor 2003).

Airport-Larkfield-Wikiup Sanitation Zone

The Airport-Larkfield-Wikiup Sanitation Zone recycles 100 percent of the wastewater it treats. The treatment plant disposes tertiary effluence by irrigating 311 acres of land on Airport property, located in the Wikiup, Larkfield area (NCRWQCB 2001c).

7.2.2.3 Effects of WWTP Activities on Listed Salmonids in the Russian River

The SRSWRS, Forestville CSD, Occidental CSD and Town of Windsor WWTP all have permits to discharge treated wastewater into Russian River tributaries located in the Guerneville and Mark West watersheds (e.g., Jones Creek, Dutch Bill Creek, Mark West Creek, and Laguna de Santa Rosa). These municipalities are only permitted to discharge wastewater at a rate of 1 percent of stream flow, except for the SRSWRS, which is permitted to discharge at rates up to 5 percent of flow. All effluent must be treated to at least a secondary level. Given these relatively low rates of discharge, it is unlikely that nutrient inputs into the tributaries would change water chemistry and/or reduce oxygen levels.

The seasonal discharge prohibitions mandated by the NPDES permitting of the wastewater treatment facilities in the Russian River to provide extra protection for salmonids during the fry and juvenile period. This reduces the potential affects of chemical pollutants and other contaminants on salmonids during the life-history stages when they are most at risk from changes in habitat quality. Water recycling and conservation programs also help minimize impacts of wastewater production.

There is also the issue of treated wastewater that originates from the Russian River being discharged into the San Francisco Bay region. Given the strict controls on the seasonal timing of discharges and the level of wastewater dilution required under SFBRWQCB permits, the effect on listed salmonids is likely to be negligible.

In general, limiting wastewater discharge to winter months and instituting effluent recycling practices increases the supply of water for agricultural lands without significantly affecting salmonid habitat in the Russian River. Thus, the expected risk to salmonids due to *interrelated activities* of the wastewater treatment facilities in the project area is expected to be low.

7.2.3 Conservation Measures within the Service Areas

7.2.3.1 Water Conservation Practices by SCWA

SCWA has implemented several BMPs to conserve water usage from the Russian River. A study by Maddaus et al. (1995) determined the potential water savings, and economic costs and benefits to SCWA of implementing BMPs, and developed a water conservation program for SCWA to assist water contractors in implementing cost-effective BMPs.

The BMPs, adopted by SCWA, increase the efficiency of water usage in the Russian River watershed by reducing water loss during transmission to customers, educating residents about water conservation issues, and increasing water use efficiency through monetary incentives.

The following is a list of the BMPs practiced by SCWA:

- System Water Audits, Leak Detection, and Repair: Audit of the water distribution system to reduce unaccounted-for water. Audits are conducted three times a year and leak detection and repair are performed if they are cost-effective (i.e., they significantly reduce the amount of water lost during transmission).

- High-Efficiency Washing Machine Program: SCWA provides rebates to water contractor residential customers who buy water-conserving washing machines. This program is an extension of the PG&E purchase of water-conserving washing machines Energy Rebate Program.

- Public Information Program: SCWA has drafted a public information plan to increase awareness of the importance of water conservation. Information is made available to the public through tri-fold bill stuffers, press releases, marketing on radio and television, and at fairs and sporting events.

- School Education Program: SCWA offers a Water Education Program (WEP), free of charge, to all public schools within the service area of the water contractors. The program is designed to help educators teach students the value of water as an important natural resource. The WEP includes direct instruction for classroom and field studies, educator workshops, biannual educational newsletter, distribution of water education calendar, and speakers bureaus throughout the service area.

- Wholesale Agency Assistance Program: SCWA's Water Transmission System fund provides approximately $2 million annually for water conservation and water education programs to help water contractors implement cost-efficient water conservation programs. SCWA also provides technical support and information to contractors on a regular basis and upon request.

- Conservation Pricing: SCWA is a wholesale water agent that sells water to its contractors at a uniform rate. In general, the uniform commodity rate is relatively high compared to the monthly service charge, which acts as monetary incentive for customers to reduce water usage.

- Conservation Coordinator: The SCWA conservation coordinator is responsible for coordination and oversight of conservation programs and BMP implementation in the service area of the water contractors.

7.2.3.2 Water Conservation Programs Implemented by the Water Contractors

SCWA has required that all eight of its retailers join the California Urban Water Conservation Council and commit to implementing the 14 BMPs of urban water conservation. In so doing, SCWA becomes the first region in the state to have 100 percent membership in this council.

Below are the most common water conservation measures currently practiced by the water contractors:

- Residual Water Audits and Plumbing Retrofitting: This measure targets residents in an effort to reduce indoor and outdoor water use, especially during peak-use periods (daytime during the summer). Homes with the highest water usage are offered a free audit that includes water conservation measures (e.g., low-flow showerheads and leak repair) and developing an irrigation system.

- System Water Audits, Leak Detection, and Repair: Audit of the water distribution system helps reduce unaccounted-for water. Audits are conducted three times a year and leak detection and repair are performed if they are cost-effective (i.e., they significantly reduce the amount of water lost during transmission).

- Installation of Water Meters: The installation of meters on residential water connections is required to help curb use, especially during peak periods. Metering has been shown to reduce residential consumption by up to 10 percent for indoor use, and 25 percent for outdoor use.

- Large Landscape Conservation Program and Incentives: Audits are conducted to increase the efficiency of water use on landscapes containing more than 3 acres of turf. The object of these audits is to reduce peak water use by applying methods developed by the California Department of Water Resources, and to help ensure accurate irrigation maintenance schedules throughout the year. Audits can reduce water demand on large landscapes by up to 14 percent.

- Commercial/Industrial/Public Incentives for Irrigation System Upgrades: Rebates are offered to customers who install devices or apply watering techniques that reduce water use by more than 1,000 hundred cubic feet per year, over at least a 5-year period. Installation of state-of-the-art technology offered by the irrigation industry can result in average water savings of 15 percent for irrigators.

- Low Water-Use Landscape Ordinance: These are laws requiring the use of low water-use plants and efficient irrigation systems in landscape design for any newly developed commercial industry, public parks, and multi-family residents. Compliance with the ordinance can achieve savings of 20 percent for newly landscaped areas.

- Commercial/Industrial/Public Indoor Water Audits: This measure targets commercial, industrial, and public water users. Building owners are contacted and offered a free interior water audit and sufficient incentives to achieve implementation of audit findings. The long-term goals of the audit include reducing leaks, optimizing cooling tower operations, implementing process water improvements, and incorporating recycling retrofits. Audits are repeated every 5 years to maintain or improve conservation levels. On average, audited sites reduce their water demand by approximately 13.5 percent.

- Commercial/Industrial/Public Outdoor Water Audits: This measure targets commercial, industrial, and public water users and is similar to residential large landscape audits. One of the key goals of this management practice is to establish the correct watering schedule to maximize water efficiency. Irrigation audits of this type on outdoor properties save approximately 14 percent of exterior water use.

- Water-Efficient Landscape and Irrigation System Incentives: This program offers incentives to single and multi-family homes to install water-efficient irrigation systems for landscaping. To qualify, customers must have drip irrigation for plants, system timers, and rain sensors. Homes that install efficient irrigation systems can reduce outdoor water usage by almost 20 percent.

- Ultra Low-Flush Toilet Replacement: Water contractors offer a rebate to customers who replace high-use toilets with 1.6 gallons per flush models. The installation of these toilets is estimated to reduce interior water use by 14.7 percent.

- <u>Incentives for Commercial/Industrial/Public Toilet/Shower Replacement:</u> Cash rebates are offered to encourage replacement of existing toilets and urinal valves in the commercial/industrial/public sectors that use more than 1.6 (toilets) and 1.0 (urinals) gallons per flush. Low-flow showerhead replacement is encouraged for commercial/industrial/public customers that have a significant number of showerheads (e.g., schools). This translates into water savings of 15.4 gallons per employee per day.

The eight primary water contractors are implementing most of these conservation programs, to some degree. Table 7-3 shows the estimated yearly water savings by the cities served by the water contractors as a result of implementing conservation practices. Each value in the table represents the estimated water savings for each city and was calculated by summing up the estimated water savings for several different recycling programs. By adding up all the values for each city, the total estimated water savings is about 19,930 AFY, which is about 3 times the savings projected for the WSTSP (see Section 4.2). Note that the values in the table may underestimate the effectiveness of these programs, as the water savings for many conservation activities are hard to estimate directly (e.g., savings from educational programs).

Table 7-3 Water Savings Due to Water Conservation Practices

Water Contractor	Estimated Water Saving (AFY)
Santa Rosa	6381.1
Rohnert Park	7,869.2
Sonoma	75.6
Cotati	177.4
Forestville	72.2
Petaluma	2,186.8
North Marin Water District	1,969.8
Valley of the Moon	1,202.0

Source: SCWA 2000c

7.2.3.3 Effects of Water Conservation Practices on Listed Salmonids

The water conservation practices implemented by the water contractors, combined with the BMPs currently practiced by SCWA, will improve the efficiency of Russian River water usage. This could contribute to the maintenance of suitable habitat conditions for salmonids by reducing the amount of water diverted from the Russian River, especially during the summer. In general, the conservation practices implemented by the water contractors should help SWCA maintain adequate flows for rearing and spawning as outlined in the Flow Proposal (Section 5.2) and thus provide a slight benefit for listed salmonids.

7.2.4 SUMMERTIME RUNOFF

Most Russian River water delivered to customers within the service areas is used for internal residential and commercial purposes. After use, a portion of this water ends up in a sewer system and is piped to a waste treatment plant. Some of the water supply is also used for outdoor landscaping in the summer. This water can seep into the groundwater and/or runoff into gutters, and thus reenter the Russian River without first being treated. Currently there are no estimates on how much water is used for landscaping and the amount of runoff from landscaping that ends up in Russian River tributaries.

Any customer of one of SCWA's water contractors may use sprinklers to irrigate turf grass, gardens, landscaped areas, and trees or shrubs. Other outdoor uses for water include washing cars, filling swimming pools, uncorrected outdoor plumbing leaks, and fire hydrant use. All of these activities can contribute to the runoff of water back into Russian River streams (SCWA 2000c).

In drought years, most cities in the service area have contingency plans that allow sprinkler use only at night, typically from 7:00 p.m. to 9:00 a.m. They also try to set limits on the amount of outdoor water use by customers based on a formula that accounts for the landscaping area and the irrigation efficiency of the type of turf (or crop) being watered (SCWA 2000c).

7.2.4.1 Programs to Reduce Contamination Due to Runoff

SCWA collaborates with the City of Santa Rosa and the County of Sonoma to perform monitoring tasks in order to characterize runoff water quality. Chemical monitoring is performed for metals, organic materials, nutrients, and other parameters. Biological monitoring includes a survey of the benthic macroinvertebrate communities in riffle areas of perennial streams and bioassays using rainbow trout in sampled streams.

To reduce contaminant inputs from runoff into the Russian River, the City of Santa Rosa and SCWA have collaborated on a public outreach program to reduce pesticide use through an Integrated Pest Management Program. The goals of this program are to:

- Increase public awareness of pesticide effects on water quality.
- Reduce environmental risks associated with pesticide use.
- Provide information on less toxic pest management techniques and proper use and disposal of pesticides.
- Provide training for personnel to disseminate information about pesticides.

The most commonly used pesticide is Diazinon, which is a common household pesticide used widely in yards and gardens. It has been found in rivers and streams of California and the Pacific Northwest, in both agricultural and urban areas. Diazinon may harm fish by disrupting behaviors that usually help young salmon escape predators, reducing the insect food base available to juvenile salmon, inhibiting reproductive behavior, and causing genetic damage.

No streams or flood control channels within the NPDES permit boundaries in the Mark West Creek watershed are currently identified on the Section 303(d) list as impaired for Diazinon. A recent water sample obtained in this region also indicated low concentration levels (ENTRIX, Inc. 2001c).

SCWA, along with the City of Santa Rosa and the County of Sonoma, continues to perform chemical, bioassay, and macroinvertebrate monitoring to characterize the effects of runoff on water quality. SCWA's goal is to reduce the influx of chemical, pesticides, and other pollutants, in order to improve water quality in the basin and reduce environmental risks to fish species.

7.2.4.2 Effects of Runoff on Listed Salmonids

Summer runoff may result in inputs of nutrients, particulates, and other pollutants into the Russian River or its tributaries. While high concentrations of pollutants could occur locally near urban and agricultural areas, monitoring programs by SCWA and Santa Rosa suggest that chemical concentrations fall within safe limits for fish.

The effects of summer runoff on salmonids is likely to be small, due to the low concentrations of pesticides and other pollutants in the water column. Fry and young juvenile steelhead would be the most vulnerable to this effect, since they rear in tributaries in the Santa Rosa and Mark West Creek watersheds, where summer runoff of water, initially purchased by the water contractors from SCWA, is most likely to occur. However, given that chemical inputs are very localized in space and time, that their concentrations are low, and that they are likely to have a short residence time, the impact on listed species should be low.

7.3 NON-NATIVE PREDATORS STOCKED IN RESERVOIRS FOR RECREATIONAL FISHING

The impounded water at Lake Mendocino and Lake Sonoma is used for maintaining non-native recreational fisheries. These reservoirs provide habitat that is conducive to the production of stocked warmwater fish species, some of which are potential predators of salmonids. Following the introduction of warmwater game fish, such as largemouth bass, smallmouth bass, redear sunfish, bluegill, green sunfish, there is no need for subsequent stocking. Striped bass will not spawn in a reservoir. Currently, the CDFG only stocks striped bass periodically into Lake Mendocino (but not Lake Sonoma), although they also plant trout upstream of Lake Mendocino (M. Grissin, Mendocino Parks and Recreation, pers. comm. 2003). Because these fisheries could not exist without the water management of the reservoirs, the stocking of non-native fisheries is an *interrelated activity* to the project.

Maintenance activities associated with the fisheries behind the dams provide source populations that may help to maintain non-native predatory species in the Upper Russian River and Dry Creek. Persistent populations of predatory fish are already well-established throughout the watershed due to seeding when the reservoir fisheries were originally started. If escapement from the reservoirs were high enough, these source populations could intensify predation pressures on juvenile salmonids, causing a decrease in their survival rates.

Although the potential for predatory fish to escape from Lake Mendocino to the East Fork still exists, the escape rate is likely to be low because water intake structures are located near the bottom of the dam (approximately 200 feet below the spillway). In fact, only one striped bass has been observed in the East Fork during SCWA monitoring studies conducted over the past several years (S. White, SCWA, pers. comm. 2003b). Passage of predators through Coyote Valley Dam would be limited in the summer, when Lake Mendocino becomes thermally stratified. Stratification results in low temperatures and DO levels at the intake structure that are unfavorable for warmwater predators, and thus should impede their passage into the Russian River.

Lake Sonoma also becomes thermally stratified during the summer and DO in the hypolimnion is gradually depleted near the intake valves on Warm Springs Dam. Temperature and oxygen stratification restrict habitat for the warmwater fish species in the reservoir to surface waters. Because water at Warm Springs Dam is drawn from the deeper depths of the reservoir, bass, pikeminnow and other predatory species are less likely to be entrained in the outflow. The reservoir is not stratified during the winter; however, coldwater conditions found below the dam are likely to negatively affect predator survival should they escape during this period. Although limited sampling data exists, it is unlikely that large populations of predators would be present in Dry Creek, due to dam operations.

Although the potential exists for warmwater predatory fish species to escape from Lake Mendocino and/or Lake Sonoma, it is unlikely that the rate of escape would have a substantial affect on the large predator populations that already exist in the Russian River and Dry Creek. Thus, the risk to listed salmon species from the reservoir fisheries is likely to be very low relative to baseline conditions.

7.4 RECREATIONAL FISHING FOR HATCHERY PRODUCED STEELHEAD IN THE RUSSIAN RIVER

Recreational fishing is available throughout the year on the Russian River mainstem and Dry Creek for hatchery steelhead, as well as smallmouth bass, catfish, and shad. Fishing is prohibited in the tributaries. While fishing in the mainstem is permitted all year, most steelhead fishing is done from October through March when the adults return to spawn (CDFG 2003). Because recreational fishing for hatchery produced steelhead can potentially harm listed salmonids and would not exist, but for the proposed hatchery program, it is an *interrelated activity* of the project.

The prohibition on take of naturally-spawned steelhead reduces direct fishing mortality, however, indirect effects due to accidental hooking and harassment can still affect wild adults. For instance, in 1999, the CDFG steelhead report-restoration card program reported that a total of 454 fishing trips were taken by the relatively small number of anglers (143) who voluntarily returned their steelhead report cards. The total catch of steelhead from these fishing trips was estimated to be 235. Of these, 107 were naturally-spawned fish and the remaining 138 were produced in the hatcheries. Seven wild fish were kept (presumably due to lack of knowledge of regulations) and the remaining 100 were released, while 53 of the hatchery fish that were caught were released (M. Hammer, Northwest Economic Associates, pers. comm. 2003). While the take of wild adult salmonids is probably relatively insignificant, there is a possibility that hooking and handling could pose a mortality risk to adult spawners.

There is also the potential that the recreational fishery could harm juveniles. Because juveniles are much smaller than adults, accidental hookings are more likely to have detrimental effects (although how often this happens is unknown). More importantly, however, fishers wading in the Russian River could stress rearing salmonids and accidentally destroy redds by stepping on them.

There appears to be a moderate risk of direct take of wild steelhead due to fishing; however, the risk of injury due to hooking may be significant. It is also possible there is a small risk to coho salmon and Chinook salmon, as they could be hooked as by-catch during the fishing season. There is, however, no information on the effects of the recreational fishery on mortality rates of coho salmon or Chinook salmon.

7.5 CHANNEL MAINTENANCE ON PL 84-99 (NONFEDERAL) SITES IN RUSSIAN RIVER AND DRY CREEK

SCWA and MCRRFCD are responsible for channel maintenance activities related to the Coyote Valley Dam Project at levees along the Upper Russian River. This includes channel maintenance conducted on federal sites and inspection of PL 84-99 (nonfederal) sites (evaluated in Section 5.4).

Sonoma and Mendocino counties originally worked through the USACE to perform maintenance work on the river. Inspections were performed on the nonfederal levees in the mainstem Russian River and the property owners were informed of the needed repairs. In general, the USACE inspected private levees and then instructed landowners on how to minimize affects of federal flood control works, to minimize the potential of destruction to property. In exchange, the landowners received property insurance against damages due to flooding. Should landowners fail to make repairs recommended by the USACE, then their insurance is revoked.

To carry out maintenance on nonfederal sites, landowners may be required to obtain a Section 404 permit from the USACE. The USACE must weigh the need to protect aquatic resources against the benefits of the proposed development before they grant a permit. USACE policy requires applicants to avoid impacts to wetlands and other U.S. waters to the extent practicable and take measures to compensate for unavoidable impacts (Environmental Protection Agency 2003b).

The effects of the *interdependent activity* of maintenance at nonfederal sites on salmonids are a result of compliance by landowners to the maintenance recommendations established by USACE and monitored by SCWA. Recommended actions for the Russian

River at the nonfederal sites are primarily for erosion control and include patching of holes in the levee surface, restoring riprap at the base of some levees, and removing vegetation from the levee face. Compliance with these recommendations results in bank stabilization and the reduction of logjams in the Upper Russian River, which can reduce sediment loading of spawning grounds and improve fish passage.

Potential *interdependent effects* related to maintenance of levee stabilization projects may be both positive and negative for salmonids. Positive effects are associated with reduction or prevention of erosion and resulting sedimentation in the channel. Negative effects may be associated with loss of riparian shading and increased water temperatures. Bank stabilization techniques may reduce the complexity of instream cover naturally provided by undercut banks, and exposed root wads. Additionally, the recruitment of spawning gravels, which are often supplied by natural bank erosion processes, may be impeded by bank stabilization structures.

7.6 City of Ukiah's Hydroelectric Facility

The City of Ukiah owns, operates and maintains the Lake Mendocino Power Project (LMPP) at Coyote Valley Dam. The project was added externally to the downstream base of Coyote Valley Dam in 1986 at a cost of $22 million (*Interim Report 7*, Hydroelectric projects operations, ENTRIX, Inc. 2000b). The LMPP is operated under a 50-year FERC license (Project No. 2481-001) issued in 1982. The City of Ukiah belongs to the Northern California Power Authority, which owns and operates various power generation plants land throughout California and provides power to their member. The City of Ukiah has used the LMPP to supplement other power sources within their system. The LMPP has no contractual minimum power requirements. Power has been generated in the past when releases were made by the USACE.

The FERC permit requires that the LMPP maintains downstream DO level at 7.5 mg/l at least 90 per cent of the time with a minimum requirement of 7 mg/l and a median monthly value of 10 mg/l for the year (FERC 1982). When operating, the LMPP is also required to provide between 7 and 15 cfs of water to the CVFF (FERC 1983).

The hydraulic turbines can operate at flows between 175 and 400 cfs; power generation is possible at flow below 175 cfs. To initiate or terminate hydroelectric operations, the City of Ukiah must switch a Tainter gate. To make the switch, the City of Ukiah must make a request to the USACE to close the slide gates. For this process, the USACE would stop water releases at Coyote Valley Dam for approximately 5 hours during the switch. Because the City of Ukiah could not switch the Tainter gate without the water management operations at Coyote Valley Dam, stopping flows to switch the Tainter gate is an *interrelated activity* to the project.

The USACE has made a recommendation to the City of Ukiah to modify the Tainter gate. This modification would allow the city to initiate or terminate hydroelectric operations without the need to stop releases from the dam. In order to make the required modifications to the Tainter gate and to continue operations of the Lake Mendocino Power Project, the City of Ukiah will undergo a Section 7 consultation with USACE.

Because this consultation will require a determination of the project effects on listed salmonids and their habitat, the operation of the hydroelectric facility is not considered in this BA.

7.7 THE EFFECTS OF INTERRELATED/INTERDEPENDENT ACTIVITIES

7.7.1 COHO SALMON

The *interrelated/interdependent activities* that could affect coho salmon include water distribution wastewater discharge, summertime runoff, recreational fishing, and predator escapes from reservoirs.

Water Distribution

The primary risks to coho salmon from the distribution of SCWA water to the water contractors would be due to accidental spills from stage tanks and leakage from transmission pipelines of treated water containing trace concentrations of drinking water treatment chemicals, primarily chlorine. Should such an event occur, the effects are likely to be highly localized. The primary areas where spills could affect coho salmon are Santa Rosa Creek, Laguna De Santa Rosa, and Green Valley Creek. All of the water contractors follow the SPCC plans, which are design to reduce accidents. Thus, the risk to coho salmon from the effects of the *interrelated activities* associated with water distribution to the water contractors is likely to be very small.

Wastewater Discharge

The discharge of wastewater into tributaries where coho are present (principally, Mark West Creek, and Laguna de Santa Rosa) is expected to have relatively minor effects on coho salmon, as coho abundance is low in these tributaries. Wastewater treatment plants that discharge into streams in the San Francisco Bay are unlikely to affect coho salmon, as they are currently thought to be extinct in the Bay Area watersheds (Brown, et al. 1994). Coho salmon runs, however, were historically present in the Bay Estuary, so discharges into San Francisco Bay tributaries could have an effect on the future recovery of coho salmon in this region. The severity of the risk posed to coho salmon depends on the amount of discharge relative to streamflows and the ability of treatment plants to remove contaminants. Currently, most treatment plants cannot discharge at a rate greater than 1 percent of the receiving flow (except for Santa Rosa WWTPs), so the concentration of contaminants into streams is expected to remain low. Discharge into the streams occurs when flows are higher (during and after the winter rains).

The greatest potential for contaminants to affect coho salmon are in Laguna de Santa Rosa, where the SRSWRS is allowed to discharge treated wastewater at rates as high as 5 percent of the flow rate. The Laguna de Santa Rosa was added to a Section 303(d) list in 1990 due to high levels of ammonia and low DO concentration as a result of eutrophication due to high nutrient inputs. Although the SCWA Waste Reduction Strategy has reduced ammonia concentrations to acceptable levels, DO continues to be a problem due to nutrient-enriched wastewater deposits (NCRWQCB 2001b).

Both SCWA and the water contractors are working to increase the amount of wastewater that is recycled for agriculture and the Geysers project. This would reduce the level of effluent released back into the Russian River (and the San Francisco Bay) and would improve rearing conditions for coho salmon above baseline conditions. Given that the current abundance of coho salmon in Laguna De Santa Rosa is very low, the risk to coho salmon from the effects of the *interrelated activities* of wastewater discharge is expected to be low. Increased recycling via the Geyser Project could lower the discharge rate into Laguna De Santa Rosa, and help facilitate the recolonizing of this stream in the future.

Summertime Runoff

The effects of runoff due to lawn watering and other outdoor uses of SCWA water could pose a small risk to coho salmon. Most runoff, however, occurs in urban streams (principally in the Mark West watershed) where coho salmon rearing is limited. Runoff could increase the amount of vegetation growing in the constructed flow control channels, which would increase maintenance activities in these areas. This could lead to more sediment in the constructed channels due to workers removing excess vegetation in order to prevent channels from flooding. Excess sedimentation could degrade rearing habitat by filling in pools, increasing water temperature, and reducing prey abundance. However, since there are currently so few coho salmon rearing in the constructed flood channels, this effect is likely to be small.

Water runoff from lawns could also increase riparian vegetative growth in natural tributaries. This should improve habitat by creating more cover for rearing juveniles, reducing temperatures and increasing habitat complexity. How beneficial this is to coho salmon is hard to gage given the lack of information on the effects of summer runoff on riparian growth.

Pesticide and chemical contamination of rearing streams are also a potential consequence of summertime runoff, however, studies have shown that most pollutants are washed into the Russian River during the first winter storms (i.e., first flush). However, these high concentrations do not last very long as chemicals are quickly dissipated even in tributaries such as Laguna de Santa Rosa (Katznelson et al. 2003). After the first flush, concentrations appear to remain low for the rest of the year (ENTRIX, Inc. 2001c). Thus summertime runoff from lawn watering and other outdoor uses are unlikely to negatively affect coho salmon. SCWA will monitor chemical levels to ensure that increased build-up of pollutants does not become a problem in the future.

Recreational Fishing

Recreational fishing for hatchery steelhead and other species, using both fly and conventional lure, occurs from October through March when steelhead adults return to spawn. In Dry Creek, findings from the CDFG steelhead report-restoration card program suggest that up to half of the fish caught are native steelhead or other salmonid species (M. Hammer, Northwest Economic Associates, pers. comm. 2003). Thus, there is a small possible risk to migrating and spawning adults as a result of bycatch during recreational fishing period. Given that coho populations are currently located in tributaries to the lower Russian River, the risk of incidental take is likely small.

Hooking stress following release could potentially lead to mortality of migrating adults. Also, fishing could stress rearing juveniles, especially if recreational fishers wade in streams and step on redds (increased egg mortality). In general, there are no studies on the level of take of coho salmon due to the steelhead hatchery fishery. The risk to coho salmon adults is probably small and is not expected to change from baseline conditions.

Predator Escape from Reservoirs

Several self-sustaining populations of predatory fish species currently exist in the Russian River, which were introduced following the completions of Coyote Valley and Warm Springs dams. Because the current rate of predator escape from reservoirs is likely to be low due to the placement of intake valves at the bottom of the dams, the continuation of the fishery in Lake Sonoma is not expected to result in any appreciable increase in predation rates on coho salmon. Thus, the risk to coho salmon is unlikely to change relative to baseline conditions.

Maintenance at PL 84-99 Sites

There are no expected effects from maintenance at PL 84-99 sites as these activities occur in the upper mainstem, where coho salmon are not present.

7.7.2 STEELHEAD

Activities that are *interrelated/interdependent* to the project that could affect steelhead include water distribution, wastewater discharge, summertime runoff, recreational fishing, predator escapes from reservoirs, and maintenance at PL 84-99 sites.

Water Distributions

The risk to steelhead from water distribution is very low and similar to those for coho salmon. Streams where there is a small localized risk due to accidental spillage are primarily Santa Rosa and Green Valley Creeks.

Wastewater Discharge

The discharge of wastewater into Russian River tributaries between mid-fall and early spring is expected to have less of an effect on steelhead than coho salmon as they do not rear in the Laguna De Santa Rosa (which is probably the stream most affected by wastewater discharge). The only streams in the Russian River that have steelhead and receive treated wastewater are Dutch Bill Creek and Mark West Creek (see Table 2-7). Steelhead, however, are also found in Schell Slough and Petaluma Creek, which receive effluent from the Sonoma Valley CSD and the Petaluma WWTP. While these streams drain into the San Francisco Bay, steelhead populations in this region belong to the same ESU as those in the Russian River. Thus, at the level of the ESU, there is a small risk to steelhead due to the *interrelated activities* associated with the discharge of treated wastewater originally purchased (or diverted) from SCWA.

Summertime Runoff

Interrelated effects on steelhead due to runoff from watering of lawns and other outdoor activities are most likely to affect rearing habitat in Mark West Creek and possible Dutch Bill Creek. Potential effects to steelhead are similar to those described for coho salmon (see above).

Recreational Fishing

Instream recreational fishing season for hatchery steelhead is from October through March throughout the Russian River, using both fly and conventional lure. Hatchery steelhead have a clipped adipose fin to distinguish them from naturally-spawned steelhead. Although this distinction does not stop recreational anglers from catching them, it indicates they are to be released after they are caught. Evidence suggests that 50 to 100 wild adult steelhead are caught and released each year (Northwest Economic Associates 2003). This could result in increased mortality to adults as a result of injuries sustained during hook and release, although the use of barbless has been shown to significantly reduce hooking mortality rates (Mongillo 1984).

Because the mainstem Russian River is primarily a migration corridor connecting steelhead spawning habitat, recreational fishing on hatchery steelhead and other species could affect spawning success. The risk to wild steelhead is probably greater than to other listed salmonids because they are more similar in to hatchery steelhead and therefore are more likely to be accidentally caught. However, this risk to wild steelhead from recreational fishing is not expected to change from baseline conditions.

Predator Escape from Reservoirs

Current rates of non-native predation on steelhead are primarily a result of past introductions when the fisheries at Lake Sonoma and Lake Mendocino were first established. Thus, predation pressures resulting for the non-native fisheries species are not changing relative to baseline conditions. Risks to steelhead are similar to those for coho salmon.

Maintenance at PL 84-99 Sites

Channel maintenance on PL 84-99 sites could potentially have negative effects on salmonids due to loss of riparian shading, sedimentation, and a reduction of instream cover. However, since maintenance operations on PL 84-99 sites are infrequent, affect a limited area of the mainstem, and require a Section 404 permit, which gives USACE authority to regulate discharge of dredged or fill materials into streams. In general, permit holders would be required to avoid wetland impacts where practicable and provided compensation for any unavoidable impacts through restoration activities. This Section

404 permit program should reduce negative effects to salmonid habitat from maintenance practices. Thus, the risk to steelhead is expected to be small.

7.7.3 Chinook Salmon

The interrelated/interdependent project effects that could affect Chinook salmon include wastewater discharge, recreational fishing, predator escapes from reservoirs, and maintenance at PL 84-99 sites.

Water Distributions

Chinook salmon primarily spawn and rear in Dry Creek and in the mainstem Russian River above Healdsburg. Therefore there are no foreseen effects of water distribution on Chinook salmon.

Wastewater Discharge

There are no expected effects of the *Interrelated activities* associated with wastewater discharge on Chinook salmon in the Russian River, as discharges occur in tributaries to the lower mainstem. Chinook salmon are found in San Francisco Bay and there is a Chinook hatchery on Petaluma River. However, any effect on natural spawning Chinook salmon in the Bay Area due to the discharge of treated wastewater purchased from SCWA is likely to be incredibly small.

Recreational Fishing

Adult upstream migration of Chinook salmon occurs between the start of October through mid-January. Because recreational fishing for hatchery steelhead occurs from October through March, there is a potential for incidental injury or mortality to upstream spawners. In fact, there is currently evidence that anglers are beginning to target adult Chinook salmon (S. White, SCWA, pers. comm. 2003b), although the overall effect of this behavior on abundance is unknown. Because the mainstem Russian River is the primary spawning habitat for Chinook salmon, there could also be injury to redds and emerging fry due to anglers wading in the stream. The overall risks to Chinook salmon are from illegal take, hooking and handling mortality, misidentification and walking on redds. It is likely that the risk to Chinook salmon populations is low, because they spawn earlier in the year than steelhead (i.e., pre-spawned adult Chinook salmon are likely to be in low abundance in the Russian River when anglers begin fishing for steelhead). However, if illegal fishing for Chinook adults increases the impacts of recreational fishing could become important.

Predator Escape from Reservoirs

Current rates of non-native predation on steelhead are primarily a result of past introductions when the fisheries at Lake Sonoma and Lake Mendocino were first established. Thus, the risk to Chinook salmon are similar to those for steelhead and coho salmon.

Maintenance at PL 84-99 Sites

Channel maintenance on PL 84-99 sites could provide some benefit to Chinook salmon migration because it helps remove fish barriers in the Upper Russian River. This should improve fish passage to spawning grounds in the Upper mainstem and increase successful passage of downstream migrating smolts. On the other hand, channel maintenance could have potential negative effects on Chinook salmon due to loss of riparian shading, sedimentation, and a reduction of instream cover. In general, maintenance operations on PL 84-99 sites are infrequent and require a Section 404 permit under the Clean Water Act, which gives USACE authority to regulate discharge of dredged or fill materials into streams. The permitting process should reduce any negative effects to salmonid habitat from maintenance practices. Thus, the risk to Chinook salmon from channel maintenance on PL 84-99 sites is expected to be small.

7.8 CUMULATIVE EFFECTS

Cumulative effects under the Section 7 Consultation are defined as effects of future state tribal, local, or private actions, not involving federal actions, that are "reasonably certain to occur" within the action area (USFWS and NMFS 1998). The term "reasonably certain to occur" has been defined by NOAA Fisheries as "new" and already permitted activities, or activities in the final stages of permitting (E. Shott, NOAA Fisheries, pers. comm. 2003). Current and future effects of existing activities, such as agriculture, forestry, urbanization, water quality management, and fishery management, are considered in baseline conditions.

Adverse impacts that are reasonably certain to occur in the action area include new water diversions. Water can be diverted from the Russian River and its tributaries under riparian rights or under appropriative rights. Riparian rights allow a landowner to divert water from an adjacent stream for use on the property. Appropriative rights are granted by the SWRCB through a permit process. Any improvements or diversion structures that are constructed to facilitate water diversion for either type of right would be subject to a Section 404 permit and subject to Section 7 consultation. Those actions are not considered cumulative effects as indicated above. However, water diversions with small pumps without dams or dikes may fit the definition for cumulative effect.

The SWRCB currently has over 100 applications pending before it in the Russian River watershed. Before the SWRCB will grant permits to these applicants, the applicants must provide the SWRCB with information regarding the availability of water for appropriation and an assessment of the fish and wildlife resources or other beneficial uses that might be affected.

To help applicants through this process, the SWRCB has recently adopted a water availability analysis procedure to meet the provisions of the California Water Code. The analysis is structured to meet the requirements in the Water Code and consider effects on listed species as the SWRCB considers the applications. The requirements to be met include:

- Water Code 1260(k): That every water right application submitted to the SWRCB must include “sufficient information to demonstrate a reasonable likelihood that unappropriated water is available for appropriation.”
- Water Code 1243: “In determining the amount of water availability for appropriation, the SWRCB shall take into account, whenever it is in the public interest, the amounts of water needed to remain in the source for the protection of beneficial uses…” Beneficial uses include preservation of fish and wildlife habitat.
- Water Code Section 1375(d): The SWRCB must decide that there is unappropriated water available to supply the new applicant.

In conducting the analyses to support the water rights application, the SWRCB is using the guidelines prepared by CDFG and NOAA Fisheries entitled Guidelines for Maintaining Instream Flows to Protect Fisheries Resources Downstream of Water Diversion in Mid California Coastal Streams. These guidelines were developed to provide procedures that would be adequate to protect and recover anadromous salmonids in coastal watersheds. The guidelines propose terms and conditions for large diversions (3 cfs or 200 AF) and small diversions (less than 3 cfs or 200 AF). The terms and conditions limit the season of diversion to December 15 to March 31, provide for minimum bypass flows that protect salmonid, and provide flows for channel maintenance. The guidelines also address cumulative impacts from multiple diversions, setting limits on the cumulative maximum rate of diversion from all sources at 15 percent of the high flow (20 percent exceedance). For projects that divert 5 percent of the total volume between October 1 and March 31, it must be demonstrated that the projects would not cause or exacerbate adverse cumulative effects to migration or spawning flows.

Although there may still be some adverse effects to listed salmonids, the implementation of the water availability analysis and the use of CDFG and NOAA Fisheries guidelines is likely to prevent significant new adverse effects to listed species.

7.9 SUMMARY

There are mainly four *interrelated/interdependent activities* associated with the proposed project: 1) the use and discharge of water sold by SCWA to its water contractors; 2) non-native predators stocked in the reservoirs; 3) recreational fishing for hatchery steelhead; and 4) channel maintenance on PL 84-99 (nonfederal) sites in Russian River and Dry Creek. The operation of the City of Ukiah’s Hydroelectric Facility also is an *interrelated activity*; however, its effects were not considered here as its operations would be subject to a separate Section 7 consultation.

In general, the effects of the *interrelated/interdependent activities* on listed salmonids are expected to be minimal and would not change from baseline conditions. The activity that would be likely to have the greatest impact to salmonids is the discharge of treated wastewater into tributaries containing rearing coho salmon and steelhead. Given that most treatment plants are using or converting to tertiary treatment, discharged during the winter, and only discharge in a few tributaries in the Russian River, any risks to salmonids are likely to be localized. There are similar localized risks associated with spillage of chlorinated water from distribution facilities operated by the water contractors; however, these events are infrequent, and are also likely to be highly localized. Such localized events could result in impacts to fish, but the number of take incidents would most decrease relative to baseline conditions as the treatment levels of wastewater improves and more recycling programs are put into action (e.g., Geysers Project).

The cumulative effects of water diverted from the Russian River by landowners under any riparian or appropriative rights would be subject to CDFG and NOAA Fisheries guidelines. These guidelines were developed to protect salmonids by limiting the season of diversion to December 15 to March 31, providing for minimum bypass flows, and ensuring proper flows for channel maintenance. While there could still be some adverse effects to listed salmonids in the future from water diversions, the CDFG and NOAA Fisheries guidelines are likely to prevent significant impacts.

The overall benefits of the project to listed salmonids, outlined in Section 6, would more than compensate for the small risks associated with the *interrelated/interdependent activities* and the cumulative effects from future water diversions. Project actives such as instream restoration programs, the Flow Proposal, the captive broodstock program, and the improvements to the diversion facilities at Mirabel and Wohler, would improve rearing and spawning habitat, and enhance fish passage. These are important steps towards the recovery of listed salmonids in the Russian River.

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9.0 Glossary

Alevin is the life-history stage of a salmonid immediately after hatching and before the yolk-sac is absorbed. Alevins usually remain buried in the gravel in or near a series of redds until the yolk-sac is absorbed, after which they swim up and enter the water column.

Alleles are different forms of a gene at a single gene locus. A single nuclear gene contains two alleles. For example, a single gene may contain one allele that codes for blue eyes and another allele for brown eyes, or the gene may contain two alleles that code for blue eyes. Differences arise by mutation and are inherited by offspring.

Allele Frequency is the frequency of an allele in a given population. Differences in allele frequencies between populations are used to measure the amount of differentiation between populations.

Allozymes are alternative forms of an enzyme that have the same function, are produced by different alleles, and are often detected by protein electrophoresis.

Anadromous refers to a life-history in which growth and maturity occur in saltwater, but spawning and some juvenile rearing occur in freshwater.

Anadromy (adj. Anadromous) is the life-history pattern that features early juvenile development in fresh water, migration to seawater, and a return to fresh water for spawning.

Anthropogenic means caused by humans.

Approach velocity is the calculated velocity component perpendicular to the fish-screen face.

Bank Storage Water stored in a streambank, usually infiltrating during a high flow.

Bank Full Discharge The discharge corresponding to the elevation of the top of stream channel just before it begins to flood**.**

Bar a mound of alluvium (sand or larger substrate materials) that forms in the stream channel.

Best Management Practice (BMP) Term used for management practices or prescription designed to protect the environment.

Artificial propagation of salmon refers to the practice of manually spawning adult fish and rearing the progeny in hatcheries, egg boxes, remote site incubators, or other facilities before release into the natural environment.

Biological Opinion is a document that includes: (1) the opinion of NOAA Fisheries as to whether or not a federal action is likely to jeopardize the continued existence of listed species or result in the destruction or adverse modification of designated critical habitat; (2) a summary of the information on which the opinion is based; and (3) a detailed discussion of the effects of the action on listed species or designated critical habitat. [50 CFR §402.02, 50 CFR §402.14(h)]

Bottleneck is a sharp reduction of a breeding population's size to a few individuals. It may have genetic consequences for the population.

Buildout refers to water supply and demand conditions at full implementation of the supply and transmission facilities authorized in the WSTSP.

Channel Pattern the configuration or plan view of the stream as seen from above.

Constructed Flood Channels stream channel that have been modified or new constructed channel to carry water during flood conditions**.**

Composite Population refers to the population that is comprised of both the hatchery-reared and naturally spawned population components.

Conservation is the use of artificial propagation to conserve genetic resources of a fish population at extremely low population abundance, and potential for extinction, using methods such as captive propagation and cryopreservation.

Cover anything that provides protection from predators or shelter from velocity, temperature or other adverse conditions**.**

Critical Habitat for listed species consists of: (1) the specific areas within the geographical area occupied by the species, at the time it is listed in accordance with the provisions of section 4 of the ESA, on which are found those physical or biological features (constituent elements) (a) essential to the conservation of the species and (b) which may require special management considerations or protection; and (2) specific areas outside the geographical area occupied by the species at the time it is listed in accordance with the provisions of section 4 of the ESA, upon a determination by the Secretary of the U.S. Dept. of the Interior that such areas are essential for the conservation of the species. [ESA §3 (5)(A)]

D_{50} is the median size of gravel as measured by the diameter of a particle – the diameter of 50 percent of particles.

Dendogram is a graphic representation of genetic-relatedness between populations, generally in the form of a tree with branches.

Deposition the accumulation of material onto the streambed.

Diploid refers to a genome when it contains two copies of each of its chromosomes. Microsatellite DNA is diploid, MtDNA is not (see haploid).

Diversion removal of surface water from a stream channel or lake

DNA (deoxyribonucleic acid) is a complex molecule that carries an organism's heritable information. The two types of DNA commonly used to examine genetic variation are mitochondrial DNA (mtDNA), a circular molecule that is maternally inherited, and nuclear DNA, which is organized into a set of chromosomes).

Domestication can occur when artificial selection in a hatchery environment produces fish with adaptations to the hatchery environment, but may result in loss of adaptations to the natural environment.

Effective Population Size is a mathematical construct that estimates the number of effectively breeding individuals in a population. It takes into account skewed sex ratios and variance in progeny number, as well as the actual number of breeders in a population.

Effective screen area is calculated by subtracting fish-screen area occluded by structural members from the total screen area.

Effects of the action are the direct and indirect effects of an action on the species or critical habitat, together with the effects of other activities that are interrelated or interdependent with that action. These effects are considered, along with the environmental baseline and the predicted cumulative effects, to determine the overall effects to the species for purposes of preparing a biological opinion on the proposed action. [50 CFR §402.02] The environmental baseline covers past and present effects of all federal actions within the action area. This includes the effects of existing federal projects that have not yet come in for their Section 7 consultation.

Electrophoresis is the movement of charged particles in an electric field. This process is an analytical tool used to detect genetic variation revealed by charge differences on proteins or molecular weight in DNA. Data obtained by electrophoresis can provide insight into levels of genetic variability within populations and the extent of genetic differentiation between them.

Embeddness the degree larger particles of sediment (gravel, cobble, or boulders) are surrounded and/or covered by smaller particles of sediment.

Endangered species is a species in danger of extinction throughout all or a significant portion of its range.

Environmental baseline is the past and present impacts of all federal, state, or private actions and other human activities in an action area, the anticipated impacts of all proposed federal projects in an action area that have already undergone formal or early Section 7 consultation, and the impact of state or private actions that are contemporaneous with the consultation process. [50 CFR §402.02]

Epistasis is the breakdown of coadapted gene complexes.

Escapement is the number of adult fish that "escape" fishing gear to migrate upstream to spawn.

Eutrophic is a water body characterized by high nutrient levels and phytoplankton productivity, and low water clarity. For example, Clear Lake.

Evolutionarily Significant Unit (ESU) is the NOAA Fisheries definition of a distinct population segment (the smallest biological unit that will be considered to be a species under the Endangered Species Act): A population will be/is considered to be an ESU if 1) it is substantially reproductively isolated from other nonspecific population units, and 2) it represents an important component in the evolutionary legacy of the species.

F Statistics: (e.g., $\mathbf{F_{ST}}$ $\mathbf{F_{IS}}$) (Wright 1931, 1943) measure the average genetic correlations within and between populations. An F_{ST}=1.0 between two populations indicates very divergent populations; F_{IS} is a measure of the genetic variance within a population.

$\mathbf{F_X}$ refers to generations removed from the parental generation. F_1 refers to the progeny of a given parental cross, F_2 refers to the offspring of those progeny. For example, F_1 refers to children and F_2 refers to grandchildren.

Fingerling a large fry usually the length of a human index finger.

Fitness is the capacity of an individual to leave fertile offspring to the next generation. It is the relative probability of survival and reproduction for a genotype.

Fluvial pertains to rivers and river action.

Fork length a measurement length for a fish from the tip of snout to the fork of the tail

Formal consultation is a process between NOAA Fisheries and a federal agency or applicant that: (1) determines whether a proposed federal action is likely to jeopardize the continued existence of listed species or destroy or adversely modify designated critical habitat; (2) begins with a federal agency's written request and submittal of a complete initiation package; and (3) concludes with the issuance of a biological opinion and incidental take statement by NOAA Fisheries. If a proposed federal action may affect a listed species or designated critical habitat, formal consultation is required (except when NOAA Fisheries concur, in writing, that a proposed action "is not likely to adversely affect" listed species or designated critical habitat). [50 CFR §402.02. 50 CFR § 402.14]

Freshet is a sudden rise in the water level of a stream or flooding caused by heavy rains or snow melt.

Fry refers to the stage in the salmonid life-history when the juvenile has absorbed its yolk sac and leaves the gravel of the redd to swim up into the water column.

Gamete a reproductive cell that is haploid, refers to both eggs and sperm.

Genes are the functional units of heredity, each being comprised of two alleles.

Genetic distance is a quantitative measure of genetic differences between a pair of samples.

Genetic drift is a stochastic process of genetic change through random changes in allele frequencies. These random changes can lead to loss or fixation of alleles in a population, and the magnitude of the effect is influenced by population size.

Genotype is the specific allelic composition of a cell, commonly for a gene or set of genes.

Habitat complexity refer to structurally complex habitat which can include large and small substrates, abundant cover objects or a diversity of water velocities and depth in close proximately.

Haploid is a genome when it contains one (not two) copies of each of its chromosomes. MtDNA is haploid.

Haplotype is the specific allelic composition of a haploid cell.

Hardy-Weinburg equilibrium is a specific, stable frequency distribution of genotypes in a population that results from random mating without mutation, migration, natural selection, or random drift.

Harvest Bycatch is capture of non-target species in a harvest activity. For example, a harvest effort directed at hatchery steelhead may result in bycatch of Chinook or coho salmon, or even of wild steelhead.

Hatchery Fish is a fish that has spent some part of its life-cycle in an artificial environment and whose parents were spawned in an artificial environment.

Heterozygosity is a measure of allelic diversity at a locus (or averaged over several loci) whereby alternate alleles at a locus are different.

Heterozygous is the condition of having two different alleles at a given locus of a chromosome pair.

Hypoliminion is the bottom portion of the reservoir below the thermoclyne where water is cooler.

Incidental take harm, injury or harassment of a species or its habitat listed under the endangered species act that occurs as the result of a lawful activity**.**

Infinite Allele Model of Kimura and Crow (1964) is a DNA mutation model that assumes each mutation creates a new allele with a low mutation rate. Unlike the stepwise mutation model, it assumes the mutation process erases any memory of previous alleles. Nei's D and Cavalli-Sforza and Edwards Chord Distance are genetic distances based on an infinite allele model.

Integrated Harvest Program is a project in which artificially propagated fish produced primarily for harvest are intended to spawn in the wild and are fully reproductively integrated with a particular natural population.

Integrated Recovery Program is an artificial propagation project primarily designed to aid in the recovery, conservation, or reintroduction of particular natural population(s), and fish produced are intended to spawn in the wild or be genetically integrated with the targeted natural population(s). It is sometimes referred to as "supplementation."

Isolated Harvest Program is a project in which artificially propagated fish produced primarily for harvest are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Isolated Recovery Program is an artificial propagation project primarily designed to aid in the recovery, conservation, or reintroduction of particular natural population(s), but the fish produced are not intended to spawn in the wild or be genetically integrated with any specific natural population.

Life-history stage refers to the developmental stage of the fish (e.g., egg, alevin, smolt, or adult).

Linkage is the association of genes on the same chromosome.

Listed Species is any species of fish, wildlife, or plant that has been determined to be endangered or threatened under section 4 of the ESA. [50 CFR §402.02]

Locus/loci is/are the site of a gene on a chromosome, often used interchangeably with gene.

Mesotrophic is a water body characterized by moderate nutrient levels, phytoplankton productivity, and moderate water clarity. May support algal blooms.

Microsatellite DNA is a form of variable-number tandem repeats (VNTRs) composed of short tandem repeat segments of two-to-five base pairs per repeat unit (e.g., GTGTGT$(GT)_n$). Microsatellite DNA is frequently used in studies of parentage and for distinguishing closely related populations. They have some of the highest mutation rates of any molecular tools used to date, are generally considered to be selectively neutral, are thought to be inherited in a Mendelian fashion, and are easily amplified with PCR.

Mitigation is the use of artificial propagation to produce fish to replace or compensate for loss of fish or fish-production capacity resulting from the permanent blockage or alteration of habitat by human activities.

Monophyly is evolutionary development from a single ancestral form.

MtDNA (mitochondrial DNA) is a small, haploid molecule, maternally inherited, that is useful for phylogenetic reconstruction. Mitochondria are organelles in the cell that have their own DNA.

Natural Channels Stream channels that have not been modified to carry flood waters**.**

Natural Fish is a fish that has spent essentially all of its life-cycle in the wild and whose parents spawned in the wild.

Natural Population is a population that is sustained by natural spawning and rearing in the natural habitat.

NATURES (Natural Rearing Enhancement System) was developed to produce "wild-like" fish from hatcheries with increased post-release survival.

Nonanadromous describes fish that live in fresh water and do not migrate to saltwater.

Non-native fish are fish species that have been placed in a habitat by man, not occurring naturally in the region.

Non-Target Population refers to populations that are not directly supported by an artificial propagation activity, but that are affected indirectly by artificial propagation activities intended to benefit another population.

Oligotrophic is a water body characterized by very low nutrient levels and high water clarity. Do not support algal blooms. For example, Lake Tahoe.

Panmictic Population is the result of random mating within a population.

Phenotype is the physical form taken by a genetic character, or group of characters, in an individual. It is the expression of genetic information (genotype).

Phylogeny is the evolution of genetically related organisms.

PIT tag (**passive integrated transponder** tag) is an injectable, internal, radiotype tag that allows unique identification of a marked fish passing within a few inches of a monitoring site.

Polymorphic means having many forms.

Pool is a deeper area of the stream with slower velocities. The surface is usually flat with no apparent gradient**.**

Population Component refers to the naturally spawned or hatchery-reared individuals inhabiting the same river system.

Recovery means improvement in the status of listed species to the point at which listing is no longer appropriate under the criteria set out in section 4(a)(1) of the ESA. [50 CFR §402.02]

Redd(s) is the nest (or series of nests) that female salmonids dig in the streambed in which to deposit their eggs.

Resident fish are fish that spend their entire lives and complete their life history in fresh water**.**

Restriction Fragment Length Polymorphism (RFLP) analysis utilizes restriction enzymes to cut DNA strands that have nucleotide sequences specific to each enzyme. RFLP analysis can be used to detect both length variation and base substitution polymorphisms, and to detect DNA variation between individuals and between populations.

Riffle is a natural grade control that accelerates the water column producing a variety of flow velocities (critical and supercritical) which oxygenate the stream. Some substrate is often partially exposed.

Run is a swiftly flowing reach of stream with little surface agitation. May appear to be flooded riffle, substrate is usually covered by water.

Salmonid means of, belonging to, or characteristic of the family *Salmonidae*, which includes the salmon, trout, char, and whitefish. Salmonids discussed in this document include two species of Pacific salmon (Chinook and coho), and one species of Pacific trout (steelhead/rainbow trout).

SAR stands for smolt-to-adult survival.

Screen mesh opening is the narrowest opening in the screen mesh.

Section 7 refers to the section of the ESA of 1973, as amended, outlining procedures for interagency cooperation to conserve federally listed species and designated critical habitats.

Smolt used as a verb means the physiological process that prepares a juvenile salmonid to survive the transition from fresh water to saltwater. Used as a noun, smolt refers to a juvenile anadromous fish that has smolted.

Species includes any subspecies of fish or wildlife or plants, and any distinct population segment of any species of vertebrate fish or wildlife that interbreeds when mature. [ESA §3(16)]

Stock Transfer refers to the active collection of fish from one river for use in a supportive breeding program in another river. This includes the transfer of fish from one ESU to another.

Supportive Breeding refers to any artificial propagation activity aimed at increasing the abundance at any life-stage of a species.

Substrate the material composing the bed of the river or the bottom of an aquatic habitat like a lake or estuary**.**

Sweeping velocity is the flow-velocity component parallel to the fish-screen face with the pump turned off.

Target Population refers to the population intended to benefit from an artificial propagation activity.

Threatened species is a species not presently in danger of extinction but likely to become so in the foreseeable future.

Viable Population Threshold is an abundance level above which an independent Pacific salmonid population has a negligible risk of extinction due to threats from demographic variation (random or directional), local environmental variation, and genetic diversity changes (random or directional) over a 100-year time-frame.

YOY (young-of-the-year) refers to fish in its first year of life.

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10.1 INTRODUCTION

This section provides a photographic overview of the facilities and operations that are discussed in Sections 2, 3 and 4 of this BA. The intent is to allow the reader to become familiar with project components and to understanding the proposed project. The photo tour starts in the upper portion of the Russian River and proceeds downstream. The first photos are of Lake Mendocino and Coyote Valley Dam on the East Fork of the Russian River. The photo tour proceeds downstream with pictures from the flow-habitat study in the mainstem Russian River. Photographs taken during the flow-habitat study illustrate differences in habitat conditions between current flow regime and the proposed flow regime. The tour then proceeds to Lake Sonoma and Dry Creek through the confluence with the mainstem to SCWA's main diversion facilities at Mirabel and Wohler. The next section of the tour shows examples of the constructed and natural channels maintained by SCWA for flood control on the Santa Rosa Plain. The tour concludes with views of the lower river and Estuary.

Photo 1. Lake Mendocino

Photo 2. Coyote Valley Dam

Photo 3. Coyote Valley Fish Facility

Photo 4. Coyote Valley Fish Facility Raceways

Photo 5. Coyote Valley Fish Facility – Juvenile Holding Area

Photo 6. Coyote Valley Fish Facility – Juvenile Volitional Release

Photo 7. Upper Russian River near Ukiah Sewage Treatment Plant

Photo 8. Upper Russian River at Ford Property near Hopland

Photo 9. Middle Russian River near Asti

Photo 10. Big Sulfur Creek. Tributary to Middle Russian River.

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Photo 11. Lake Sonoma

Photo 12. Warm Springs Dam

Photo 13. Don Clausen Fish Hatchery below Warm Springs Dam

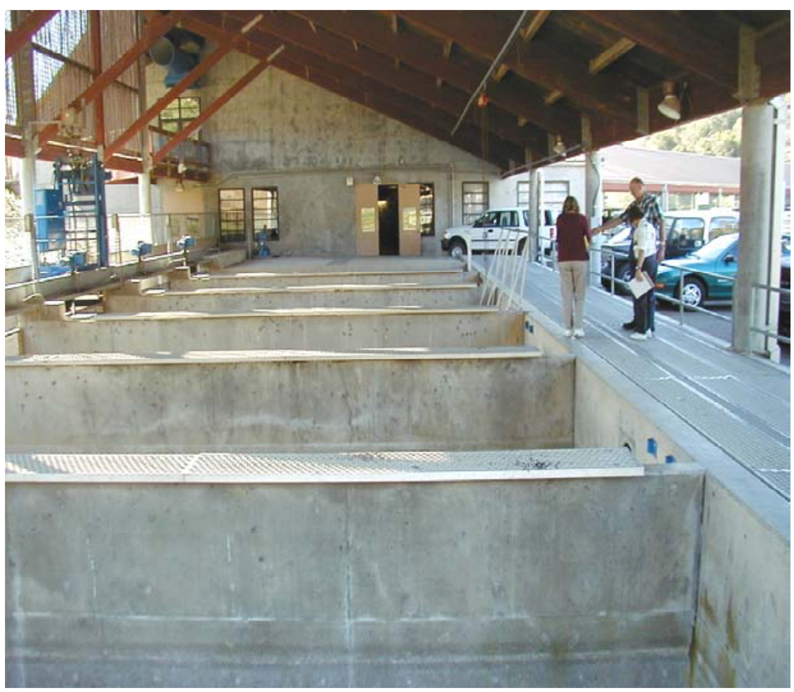
Photo 14. Don Clausen Fish Hatchery: Adult Holding Area

Photo 15. Don Clausen Fish Hatchery Aeration Facilities and Raceways

Photo 16. Don Clausen Fish Hatchery: Coho Rearing Facility

Photo 17. Dry Creek Flow-Habitat Study: Transect T-4, flow = 40 cfs

Photo 18. Dry Creek Flow-Habitat Study: Transect T-4, flow = 130 cfs

Photo 19. Dry Creek Flow-Habitat Study: Transect T-6, flow = 40 cfs

Photo 20. Dry Creek Flow-Habitat Study: Transect T-6, flow = 130 cfs


Photo 21. Dry Creek Flow-Habitat Study: Transect T-8, flow = 40 cfs


Photo 22. Dry Creek Flow-Habitat Study: Transect T-8, flow = 130 cfs

Photo 23. Dry Creek/Russian River Confluence

Photo 24. Aerial View of Mirabel Infiltration Ponds Looking Upstream. The Inflatable Dam is Located Near the Upstream End of the Ponds.

Photo 25. Wohler Pool near Inflatable Dam

Photo 26 Mirabel Dam Notching Study, Spring 2002

Photo 27. Mirabel Dam – Close-up of Notch in Dam

Photo 28. Russian River below Inflatable Dam at Mirabel


Photo 29. Top View of Intake Screens at Mirabel Diversion Facility (not operating)

Photo 30. Top View of Intake Screens at Mirabel Diversion Facility in Operation

Photo 31. Fish Ladder on West Side of Russian River below Mirabel Dam

Photo 32. Outlet of Fish Ladder below Mirabel Dam


Photo 33. Ranney Collectors at Mirabel


Photo 34. Close-up of Ranney Collector Housing at Wohler Bridge

Photo 35. Intake Screens at end of Culvert at Wohler Ponds

Photo 36. Infiltration Ponds at Wohler

Photo 37. Water Storage Tank

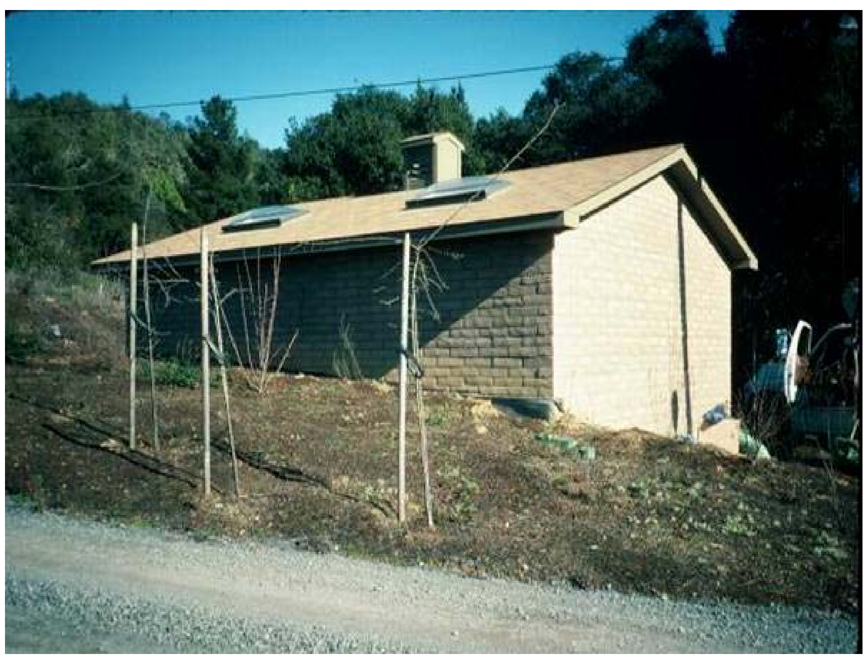

Photo 38. Booster Pump Station

Photo 39. Healdsburg Dam (seasonal)

Photo 40. Constructed Flood Control Channel. Hinebaugh Creek Downstream from Snyder Lane in Rohnert Park, Spring 200

Photo 41. Constructed Flood Control Channel. Hinebaugh Creek Upstream from Country Club Avenue in Rohnert Park, Spring 2001.

Photo 42. Santa Rosa Creek

Photo 43. Santa Rosa Creek Downstream from Fulton Road

Photo 44. Restored Creek Channel

Photo 45. Brush Creek Stream Restoration

Photo 46. Copeland Creek, Downstream of Snyder Lane. Shortly After Sediment was Excavated.

Photo 47. Copeland Creek, Upstream of Pedestrian Bridge. No Recent Sediment Removal.

Photo 48. Five Creek, Downstream from Snyder Lane

Photo 49. Piner Creek Upstream from Gordon Creek Drive

Photo 50. Middle Russian River: Healdsburg Memorial Beach, Showing Seasonal Dam

Photo 51. Lower Russian River: Monte Rio Beach

Photo 52. Russian River Estuary, Mouth Open

Photo 53. Russian River Estuary, Mouth Closed

Photo 54. Russian River Estuary Looking Upstream, Mouth Closed

Photo 55. Estuary – Aerial View Looking North

Photo 56. Russian River Estuary, Mouth Closed

RUSSIAN RIVER
BIOLOGICAL ASSESSMENT
APPENDICES

Prepared for:

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San Francisco District
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and

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Santa Rosa, California

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ENTRIX, INC.
Walnut Creek, California

September 29, 2004

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APPENDIX A

ALTERNATIVE ACTIONS

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Term	*Definition*
ASR	aquifer storage and recovery system
BMP	best management practice(s)
CDFG	California Department of Fish and Game
cfs	cubic-feet per second
D1610	SWRCB Decision 1610
DO	dissolved oxygen
FL	fork length
km	kilometer(s)
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
mm	millimeter(s)
MOU	Memorandum of Understanding
NFP	Natural Flow Proposal at buildout
NGVD	National Geodetic Vertical Datum
NMFS	National Marine Fisheries Service, now known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
TMDL	Total Maximum Daily Load
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey
WSTSP	Water Supply and Transmission System Project
YOY	young of the year

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The Memorandum of Understanding (MOU) governing the U.S. Army Corps of Engineers (USACE) Section 7 Consultation for the Russian River outlined a process to consider modifications to activities occurring in the watershed. Potential management actions were developed to address issues regarding potential adverse effects to protected species raised in the review of ongoing operations and maintenance activities in the interim reports, comments received from the Agency Working Group, the Public Policy Facilitation Committee, and the general public on the interim reports. In addition, management actions were also developed based on discussions and meetings among USACE, Sonoma County Water Agency (SCWA), National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries), formerly National Marine Fisheries Service (NMFS), and the California Department of Fish and Game (CDFG).

The management actions included in this appendix are not currently part of the proposed project, but are alternative actions that could be implemented if information collected in the future suggests they are warranted. This appendix provides descriptions of the alternative management actions being considered by USACE and SCWA, and evaluates effects on protected fish populations. The next sections are organized by facility or operational activity.

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Annual and periodic (5-year) pre-flood inspections take place at both Coyote Valley and Warm Springs dams. Releases from the reservoir must be reduced or shut down for dam inspections and maintenance. Typically, annual inspections require that flows cease for up to 2 hours, although on some occasions more time may be needed to make repairs. Reduced streamflow (dewatering of habitat) is a concern during these times.

Whenever releases from the dam are shut down, nearly all releases to the East Fork Russian River are eliminated. This results in the potential for stranding of fry and juveniles, and potential for dewatering the East Fork and mainstem Russian River from May through September.

The following sections describe two actions that could be implemented to increase minimum flow.

A.2.1 RELEASE WATER FROM THE STILLING BASIN AT THE BASE OF THE DAM TO PROVIDE FLOWS DURING PERIODS WHEN RELEASES FROM DAM ARE CURTAILED

The objective of this action is to maintain flow in the East Fork Russian River when flows from the dam are curtailed for maintenance and inspection activities.

A.2.1.1 PROJECT DESCRIPTION

During periods when the flows from the dam are curtailed, water would be released from the stilling basin below the dam. This action would supplement flows and maintain refuge habitat for a short period of time. This release would supplement the 5 to 6 cfs provided by gravity at the weir at Coyote Valley Dam, which has always been measured after flows have been halted from Coyote Valley Dam for at least 2 hours (C. Eng, USACE, pers. comm. 2003). Observations made in 1999 indicate that flows of approximately 5 cubic feet per second (cfs) could be maintained for a period of 1 to 2 hours.

A.2.1.2 EFFECTS ON PROTECTED SPECIES

This action would slow the dewatering of the stream channel and would help maintain water quality in the deeper pools that serve as a refuge for juveniles as the wetted area shrinks. Releases of 5 cfs to the East Fork Russian River may not always be maintained for the full time required to make repairs. This suggests that this action could be beneficial for short periods such as the time needed to perform inspections, but may not prevent dewatering of habitat during extended periods of time for repairs.

Scheduled inspections would occur between July 15 and October 15 (Section 4.1.1.2). Therefore, only steelhead juveniles are likely to be present. According to the evaluation criteria, a flow of 5 to 10 cfs would score a 1 for steelhead juvenile rearing (see Appendix C, Table C-2) while flows are maintained. This score indicates a severely diminished habitat quality for steelhead rearing. Because this flow could not be maintained for more than a couple of hours, the East Fork could be dewatered if inspections or repairs took longer.

As inspections would be undertaken during the mid- to late-summer when flows in the mainstem Russian River are low, reductions in flow from the East Fork could negatively affect juvenile salmonid habitat in the mainstem by eliminating a percentage of mainstem flow. During inspection and maintenance activities in June 1999, releases from the dam were near 0 cfs, about 5 cfs of flow was provided from the stilling basin, and flows were 10 to 12 cfs above the East Fork at the Ukiah gage. No stranding was documented. In contrast, September flows in the mainstem Russian River above the East Fork at the Ukiah gage are typically 1 to 2 cfs (ENTRIX, Inc. 2002).

A periodic inspection was conducted at Coyote Valley Dam on September 9, 1998. There were no bypass flows during this inspection. Streamflow was monitored 4 miles downstream from the dam. Discharge could not be measured with a current meter, but was estimated to be less than 30 cfs at that time. During this inspection, some juvenile steelhead were stranded and rescued below the dam on the East Fork to approximately 12,000 feet downstream on the mainstem Russian River below the Forks. A flow of approximately 30 cfs would result in a score of 2, indicating diminished rearing habitat quality in the mainstem.

An additional release of 5 cfs for a short time may at times be insufficient to maintain good-quality habitat in the East Fork and mainstem Russian River. However, this action would improve habitat conditions downstream of the dam and prevent dewatering of the East Fork for a limited period of time. Therefore, implementation of this action would be beneficial to juvenile salmonids.

A.2.2 Create an Enlarged Embayment below Coyote Valley Dam

The objective of this action is to create an impoundment to store additional water that could be used to provide minimum release flows during dam maintenance and inspection activities. This action is similar to the action described in Section A.2.1, but would provide a greater amount of water to maintain minimal flows for a longer period.

A.2.2.1 Project Description

Structures below Coyote Valley Dam include a stilling basin, an embayment, a rock weir, and a gaging station. This action includes either raising the height of the rock weir, or installing an inflatable dam or flashboard system to provide water storage on a temporary basis. When releases from the dam are curtailed for maintenance or inspection activities, the water stored within the embayment would be released to provide additional releases of 5 cfs and prevent dewatering of the East Fork Russian River.

The inflatable dam or flashboard system could be placed at an angle in the outlet structure to allow minimum flows past the powerhouse while conducting extended maintenance or repairs. Alternatively, for short duration inspections or repairs, the dam or flashboard system could be placed on top of the weir until the water begins to overtop it, then it could be gradually lowered. This would probably provide up to 5 cfs for up to 4 to 5 hours. Raising the weir would provide flows comparable to flows that could be provided by an inflatable dam, and would have the additional advantage of providing more water to the fish hatchery located downstream of the powerhouse.

A.2.2.2 EFFECTS ON PROTECTED SPECIES

Currently, only about 5 cfs is maintained in the East Fork Russian River for up to two hours during inspection or maintenance activities. Habitat conditions are marginal at best. An additional release of 5 cfs would improve habitat conditions.

With the proposed action, an additional release of 5 cfs, for minimum flows of approximately 10 cfs, could be maintained for up to 2 hours during annual inspections. An additional flow of 4 to 5 cfs would maintain some refuge habitat for young salmonids, and would represent a considerable improvement over current conditions.

Scheduled inspections would occur between July 15 and October 15 (Section 4.1.1.2). Therefore, only steelhead juveniles would be present. Minimum flows of 25 cfs would not be maintained in the East Fork. As discussed in Section A.2.1, a flow of 5 to 10 cfs would score a 1 for steelhead juvenile rearing (see Appendix C, Table C-2) while flows are maintained. This score indicates a severely diminished habitat quality for steelhead rearing in the East Fork. Because this flow could not be maintained for more than a few hours, the East Fork could be dewatered if inspections took longer, resulting in a score of 0. Reduced flows in the mainstem Russian River below the Forks would also result in diminished habitat.

This action would only prevent dewatering of the East Fork for a limited period of time. The resulting scores would be 1 or 0 in the East Fork, depending on the duration of the inspection or repairs, and would likely be 2 or 1 in the mainstem below the Forks.

A.2.2.3 OTHER CONSIDERATIONS

This action would not suffice to maintain minimal habitat throughout the entire inspection period. This action by itself may not be effective in preventing dewatering of the East Fork Russian River.

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USACE's main objective for flood control operation at Warm Springs Dam is to reduce peak flood discharges in Dry Creek and in the Russian River below Healdsburg to the extent possible. The criteria for flood control operation of Lake Sonoma are described in the Warm Springs Dam Water Control Manual (USACE 2003).

Channel geomorphology refers to the form of a river, which includes channel dimensions (i.e., width, depth, confinement, and entrenchment), gradient, planform, and bed material sizes. Channel geomorphology is intimately linked to the type and quality of fish habitat present. The change in hydrologic regime associated with flow regulation by dams influences channel geomorphic response.

High flows are periodically needed in a natural channel to maintain channel geomorphic conditions. The high flows mobilize the streambed and transport sediments. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids, for flushing fine sediments, and maintaining bar-pool morphology. However, if flood releases are of sufficient magnitude and frequency to regularly scour spawning gravels, incubation success may be negatively affected. Ideally, a balance, or dynamic equilibrium, occurs between periodic mobilization of the streambed, transport of sediment, sediment deposition, and stability of spawning gravels. Lack of peak flows can reduce spawning success, as can an increase in the frequency and magnitude of peak flows.

Sections 3.1 and 3.2 summarize the effects of current flood control operations on coho salmon, steelhead, and Chinook salmon in Dry Creek and the Russian River. The analyses indicate that there is a reasonably good balance between expected periodic streambed mobilization and spawning gravel stability for successful reproduction of Chinook salmon and steelhead. Coho salmon, using smaller gravels for spawning, are currently subject to a greater frequency of redd scour than either steelhead or Chinook salmon. However, some mobilization and scour of spawning gravels to transport fine sediments is necessary over the long-term in order to maintain the quality of spawning gravels.

Flood control operations at Warm Springs Dam have influenced peak flood frequencies and expected bed mobilization on Dry Creek. Based on historic (i.e., pre-dam) flow data, flood-flow magnitudes and frequencies today may be insufficient to maintain channel geomorphic conditions within Dry Creek. However, it should also be recognized that Dry Creek is likely to have adjusted channel dimensions and form to accommodate the existing regulated flow and sediment regime, thereby establishing a new channel equilibrium.

Sustained releases of flood flows have been cited as a potential cause of streambank instability in both Dry Creek and the mainstem Russian River. Prolonged release of moderate to high streamflows may influence bank erosion and thereby affect habitat conditions by contributing sediment to the channel or altering cover, shading, and other factors relevant to the riparian corridor.

The following sections present three actions that involve channel maintenance flows.

A.3.1 Manage Releases from Warm Springs Dam to Provide Channel Maintenance Flows from the Flood Pool of at least 5,000 CFS above Pena Creek at a Planned Frequency of at least 2 Events per 3 Years

The objective of this action is to ensure maintenance of geomorphic features and fluvial processes on Dry Creek downstream of Warm Springs Dam. This would be accomplished by releasing flows of sufficient magnitude and frequency to improve habitat diversity, and mobilize and transport fine sediment from spawning gravels.

A.3.1.1 Project Description

In most alluvial river systems, the natural frequency of channel maintenance flows is 2 events every 3 years. On Dry Creek, the historic (i.e., pre-dam) channel maintenance discharge was estimated to be 7,000 cfs (as a 1-day flow) downstream of the Pena Creek confluence and 5,000 cfs upstream of Pena Creek (ENTRIX, Inc. 2000). Currently, channel maintenance flows of the historic magnitude occur at a frequency of 1 event every 6 years downstream of Pena Creek and 0 events upstream of Pena Creek.

This action would release water from the flood control pool in Warm Springs Dam to approximate more closely the natural frequency and magnitude of channel-forming flows. The actual frequency would vary in response to interannual hydrologic variation. Releases would be made for channel maintenance flows when flows are high, such as after storms on the descending limb of a flood hydrograph. To ensure that the required frequency and magnitude of channel-forming flows are released, it is assumed that the managed flows would occur during the earliest storm that could provide sufficient volume. Ramping-up flows to achieve the required 5,000 cfs for 1 day would require approximately 20,000 AF of water, which would be obtained from the flood control pool.

A.3.1.2 Effects on Protected Species

Channel maintenance flows are necessary to maintain variation in stream morphology important to habitat quality, such as meanders, pools, and riffles. Channel maintenance flows also serve to refresh spawning gravels by mobilizing the streambed and winnowing the fine sediments from the gravels. However, flood releases may affect spawning habitat by scouring gravels to a depth that destroys the egg pocket. Ideally, there would be a balance between periodic mobilization of the streambed, transport of sediment, sediment deposition, and stability of spawning gravels. This evaluation assesses the potential effects of the proposed action on channel maintenance and geomorphology, scour of spawning gravels, and bank erosion.

A.3.1.2.1 Channel Maintenance/Geomorphology

High flows are periodically needed to maintain channel geomorphic conditions by mobilizing the streambed, and flushing and transporting fine sediments from the streambed. Such flows are necessary to provide suitable spawning and rearing conditions for salmonids. Releases would be made to increase the frequency of channel maintenance flows of sufficient magnitude to mobilize coarser bed materials, and to help ensure a balance between sediment supply and sediment transport. Channel maintenance flows of insufficient duration and magnitude may result in excess sedimentation of the streambed that could impair spawning or rearing habitat. Excess sediment input can "smother" spawning gravels, eggs, and alevins. Pool habitat can be diminished by sedimentation. Sedimentation can also reduce the availability of habitat for the invertebrate foodbase of salmonids. This concern is greatest at locations downstream of Pena Creek where tributaries deliver sediment to Dry Creek. However, there are no existing data that characterize sedimentation on Dry Creek, and successful spawning by steelhead and Chinook salmon has been observed.

In general, channel-forming flows should occur in approximately 2 years out of every 3 years, as a long-term average (i.e., 66 percent of years). When the channel-forming flow occurs less frequently, gravels are mobilized less frequently and sedimentation may increase, thereby reducing spawning habitat quality.

The frequency of channel-forming flows under current flood control activities was evaluated in *Interim Report 1* (ENTRIX, Inc. 2000) and in Section 5.1. The Flow Proposal is not expected to result in substantial changes in flow under flood control operations. The frequency of channel-forming flows, using historic magnitudes as a reference for evaluation, in Dry Creek below the Pena Creek tributary confluence was approximately 17 percent over a 36-year period of record (1960 to 1995), which was given a score of 2. Immediately downstream of Warm Springs Dam, channel-forming flows did not occur during the 36-year period of record, and were given a score of 0.

Significant channel geomorphic changes were apparently already underway on Dry Creek before the construction of Warm Springs Dam as a result of agricultural practices and gravel mining. A study conducted by USACE concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that it was unlikely that further channel degradation would occur, but that continued lateral instability and erosion of the incised channel banks was likely.

The channel downstream of Warm Springs Dam has adjusted in response to flow regulation, gravel mining, and other land-use activities in the watershed, and is probably continuing to adjust, seeking a new equilibrium. With an incised, widened, and encroached channel, the pre-dam, channel-forming flows used for this evaluation may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek may currently be sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed.

A.3.1.2.2 Scour of Spawning Gravels

An increase in the frequency of channel maintenance flows to improve channel geomorphology could be offset by a negative effect: a loss of spawning gravels. This is of particular concern for coho salmon because they typically use smaller-sized gravels, which are more likely to be scoured.

The risk of scour of spawning gravels is evaluated based on the number of cross-sections in Dry Creek that would initiate bed movement within each of the stream reaches evaluated at specific flow ranges (see Appendix C.1.6, ENTRIX, Inc. 2000). As flows increase and more cross-sections experience bed movement, scores are lower. Scores under this alternative action are compared to scores that would occur without the action.

Two time-periods are evaluated relative to the presence of sensitive lifestages. The first time-period occurs before spawning is over and the second is during incubation after spawning is over. Evaluation criteria during the incubation time-period are more stringent to reflect the fact that flows which disrupt spawning gravels with incubating eggs will likely have a greater negative effect on reproductive success for that year class. The final score given for each water year is the highest impact event that occurs during the year. Scoring under baseline conditions was based on a hydrologic model that simulated flows over the period of record from 1960 to 1995 (Table A-1) (ENTRIX, Inc. 2000). The larger-sized spawning gravels associated with Chinook salmon redds (D_{50} = 36 mm) compared with steelhead redds (D_{50} = 22 mm) and coho salmon redds (D_{50} = 16 mm), account for the greater stability of gravels and better overall scores for Chinook salmon spawning gravels.

Table A-1 Frequency of Scores for Dry Creek Spawning Gravel Scour under Baseline Conditions (Percent of Years 1960 to 1995)

Score	5	4	3	2	1
Coho Salmon	13.9%	5.6%	16.7%	22.2%	41.7%
Steelhead	22.2%	16.7%	33.3%	27.8%	0%
Chinook Salmon	47.2%	11.1%	27.8%	13.9%	0%

Coho Salmon

Under this action, the frequency of channel-forming flows (greater than 5,000 cfs) would occur in 2 out of 3 years. If channel-forming flows are released before the end of January (before spawning is over), a score of 2 (early season) or 1 (late season) would apply for coho salmon for those 2 out of 3 years (Table A-2), or 66 percent of years.

Table A-2 Coho Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Coho Salmon Dec. 1-Jan. 31 (before spawning is over)	Coho Salmon Feb. 1-Feb. 28 (incubation)	Score
<800 cfs	5	5	
>800-1,400 cfs	4	3	
>1,400-3,000 cfs	3	2	
>3,000-8,700 cfs	2	1	X

Under baseline conditions, a score of 2 was estimated to occur in 22.2 percent of years and a score of 1 in 41.7 percent, for a total of 64 percent of years having scores of 2 or less (Table A-1), which is similar to scores under the alternative action. Therefore, this action is not expected to result in a substantial change in frequency of scour of coho salmon spawning gravels, and would have minimal effect on coho salmon spawning conditions. Implementation of this action could improve channel geomorphic conditions without increasing the risk of scour of coho salmon spawning gravels.

Steelhead

Under this action, channel-forming flows would result in a score of 3 or 2 for steelhead if they are released before April 30 (before spawning is over) in at least 66 percent of the years (Table A-3). If they occur before spawning begins (December 1), releases for channel-forming flows are unlikely to be made after April 30. Releases for channel-forming flows are not likely to substantially affect spawning.

Under baseline conditions for steelhead, a score of 2 was estimated to occur in 27.8 percent of years and a score of 3 in 33.3 percent of years (Table A-1) (ENTRIX, Inc. 2000). Therefore, a score of 3 or less is estimated to occur for approximately 61 percent of years if this action were not implemented.

This action would increase the frequency of lower scores for gravel scour. Therefore, implementation of the action would increase the risk of scour of steelhead spawning gravels. However, steelhead spawning periods are long, and if the channel-forming flows are released early, there would still be time for successful spawning and incubation in any given year. If this action were implemented early in the rainy season, benefits to channel geomorphology could outweigh the risk to steelhead reproduction.

Table A-3 Steelhead Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Steelhead Dec. 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)	Score
<1,300 cfs	5	5	
>1,300-2,600 cfs	4	3	
>2,600-5,500 cfs	3	2	X
>5,500-12,000 cfs	2	1	

Chinook Salmon

Under this action, scores for Chinook salmon scour would result in a score of 4 if flows are released before January 31, and a score of 3 if flows are released after January (Table A-4), for a total of 66 percent of the years scoring 3 or 4. Under baseline conditions, a score of 3 or 4 was estimated to occur in 39 percent of the years (Table A-1). Therefore, potentially more Chinook salmon gravels would be scoured under this action than under baseline conditions.

Because Chinook salmon gravels are larger than steelhead or coho salmon spawning gravels, scour is initiated at larger sizes. This analysis indicates that the increased flows reach a threshold at which scour of Chinook spawning gravels would be much greater than if the action were not implemented. In contrast, scour of coho salmon and steelhead gravels was already occurring under baseline conditions, and the increased flows under this action would not appreciably increase the frequency of scour. Therefore, for Chinook salmon, benefits to channel geomorphology would likely be offset by an increased risk of scour of spawning gravels.

Table A-4 Chinook Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel-Forming Flows in 2 out of 3 Years

Flow Range	Chinook Salmon Nov. 1-Jan. 31 (before spawning is over)	Chinook Salmon Feb. 1-Mar. 31 (incubation)	Score
<3,000 cfs	5	5	
>3,000-6,000 cfs	4	3	X
>6,000-9,000 cfs	3	2	
>9,000-15,000 cfs	2	1	

A.3.1.2.3 Bank Erosion

Sustained releases of flood flows of greater than 2,500 cfs have the potential to cause streambank instability in Dry Creek. Under this action, flows of 5,000 cfs would be released from the flood control pool in Lake Sonoma in two out of every three years for a period of one day. Releases would be made when flows are already high, such as after the major peak of a storm hydrograph.

This action would increase the frequency of days per year with flows exceeding 2,500 cfs by 1 day in 2 out of 3 years. Therefore, the potential for bank erosion would increase slightly over baseline conditions. A summary of Dry Creek bank erosion scores under baseline conditions and this action are presented for two locations (immediately below Warm Springs Dam and Near Geyserville) in Table A-5. The Near Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system.

Table A-5 Percentage of Years with Bank Erosion Scores for Dry Creek under Baseline Conditions and this Action

	Score				
Location	**5**	**4**	**3**	**2**	**1**
Below Warm Springs Dam					
Baseline	58	8	8	3	11
This Action	53	17	17	3	11
Near Geyserville (below Pena Creek)					
Baseline	50	17	6	0	28
This Action	47	14	11	0	28

The percentage of years receiving a score of 4 or 5 decreases slightly under this action compared to baseline conditions. The percentage of years receiving a score of 3 (indicating between 8 and 11 days per year with flows greater than 2,500 cfs) increases relative to baseline, while years receiving scores of 1 or 2 remain constant.

Bank erosion scores are relatively good immediately below Warm Springs Dam. In approximately 28 percent of the years evaluated, streamflow conditions are conducive to bank erosion near Geyserville. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 or more consecutive days with flows exceeding 2,500 cfs, indicating prolonged high flow conditions.

It is important to note that on many days when flows exceeded the erosion threshold at the Near Geyserville location, discharge from Warm Springs Dam was low. For example, inspection of the modeled flow records indicate that in water year 1983, there were 33 days when flows exceeded the 2,500-cfs erosion threshold Near Geyserville; but on 13 of those 33 days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Of the 318 days during the modeled period of record when flows exceeded the 2,500 cfs erosion threshold, there were 114 days (36 percent of the days when flows exceeded the erosion threshold), when natural flow accretion alone below Warm Springs Dam was greater than this erosion threshold. Flow releases were either very low or smaller than natural flow accretion below the dam, so that the erosion threshold would have been exceeded regardless of flow releases from the dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm Springs Dam on downstream bank erosion. Regardless, the scoring results indicate that increasing releases from Warm Springs Dam to 5,000 cfs in 2 of every 3 years is not likely to cause prolonged flows above the threshold that initiates streambank instability and erosion in most years.

A.3.1.3 SUMMARY

Dry Creek is developing a new equilibrium in response to changes in hydrology and sediment supply associated with Warm Springs Dam and other land uses in the watershed. Therefore, channel-forming flows of historic magnitude may not be appropriate for the current channel configuration. However, in general, channel-forming flows should occur in approximately 2 years out of every 3 years, as a long-term average. Under baseline conditions, the frequency of channel-forming flows in Dry Creek is less. Implementation of this action would increase the frequency of channel forming flows and could improve channel geomorphology in Dry Creek, thereby improving habitat conditions for salmonids. The spawning gravels in Dry Creek may currently be suitable for use by coho salmon, steelhead, and Chinook salmon.

This action would result in a slight increase in the potential for scour of coho salmon and steelhead gravels, which could be offset by improvements to channel geomorphology. The action could substantially increase the potential for scour of Chinook salmon gravels as compared to baseline conditions, which would offset benefits to channel geomorphology. This action would also result in a small increase in the potential for streambank erosion, but is not likely to cause prolonged flows above the threshold that initiates streambank instability and erosion in most years.

A.3.1.4 OTHER CONSIDERATIONS

Implementation of this action would require the acquisition of conservation easements along Dry Creek to provide a connected flood plain with improved riparian function (see Section A.3.4). Increasing the frequency of channel maintenance flows could increase the potential for erosion or flooding. Any action that increases the magnitude or frequency of flood releases to provide channel maintenance flows (i.e., > 5,000 cfs) would require cooperative efforts with adjacent landowners before it was implemented. This action also would have the potential to increase channel incision. A monitoring program would be implemented, which includes measurements to detect potential channel incision or bank erosion.

A.3.2 Manage Releases from the Flood Pool of Warm Springs Dam to Provide Channel Maintenance Flows of between 1,500 and 2,500 cfs above Pena Creek

The objective of this action is to maintain geomorphic features and fluvial processes on Dry Creek downstream of Warm Springs Dam. This would be accomplished by releasing flows of sufficient magnitude and frequency to improve habitat diversity, mobilize spawning gravels, and flush fine particulates from the system, while minimizing potential effects to streambank instability.

A.3.2.1 Action Description

Winter flows of sufficient magnitude and frequency are needed to improve habitat diversity, mobilize spawning gravels, and flush fine particulates from the system. However, sustained releases of flood flows of greater than 2,500 cfs have the potential to increase the risk of streambank instability in Dry Creek. Therefore, channel maintenance flows would be managed to balance efforts to improve habitat quality (i.e., spawning gravel conditions and channel geomorphology) with the need to limit the potential for bank erosion and to limit scour of spawning gravel, while meeting USACE's objective for flood control in Dry Creek and the Russian River. Measures to reduce the potential for bank erosion would be implemented if future information determines it is warranted.

On Dry Creek, the historic (i.e., pre-dam) channel maintenance discharge was estimated to be 7,000 cfs (as a 1-day flow) downstream of the Pena Creek confluence and 5,000 cfs upstream of Pena Creek (ENTRIX, Inc. 2000). Under current flood control operations, these flows tend to occur at an average frequency of one event per 6 years below Pena Creek, and have occurred only once in the reach upstream of the Pena Creek confluence since operation of the dam. However, providing flows of that magnitude would likely result in streambank erosion.

Releases between 1,500 cfs and 2,500 cfs could be of sufficient magnitude to flush fine sediments from spawning gravels, without excessive streambank erosion. Currently, flows of 2,500 cfs or more occur about once every 1.5 to 2 years. Under this action, flows of 1,500 to 2,500 cfs would be released from the flood control pool in Lake Sonoma annually, which would be slightly more frequent than under baseline conditions. Releases would be made for channel maintenance flows when flows are high, such as after the major peak of a storm hydrograph. Timing of releases of 1,500 to 2,500 cfs would vary in response to interannual hydrologic variation. These releases would occur in *normal* and *wet* years, but may not occur in *dry* years.

If it is determined that substantial biological benefits to spawning gravel can be realized by providing flows of 1,500 to 2,500 cfs, but substantial bank erosion is likely to occur, then one of two options would be considered. If bank erosion is likely to occur only at a limited number of site-specific areas, specific actions to mitigate erosion would be considered. These actions could include bioengineered bank erosion control methods, construction of overflow channels, or purchase of conservation easements to restore some floodplain capacity. If these options are not feasible, another option would be to reduce the frequency of channel-forming flows to a level that balances benefits to spawning gravel and the potential for bank erosion. However, flows of 2,500 cfs already occur once every 1.5 to 2 years under current conditions.

A.3.2.2 EFFECTS ON PROTECTED SPECIES

A.3.2.2.1 Channel Maintenance/Geomorphology

The effects of flows of 1,500 to 2,500 cfs on channel geomorphology have not been modeled. However, flows of between 1,500 cfs and 2,500 cfs currently have a return period of approximately 1.5 to 2.0 years (USACE 1998).

As discussed in the previous action, despite the lack of geomorphic flows of historic magnitude, the spawning gravels in Dry Creek may currently be suitable for use by coho salmon, steelhead, and Chinook salmon. The channel downstream of Warm Springs Dam has adjusted in response to flow regulation, gravel mining, and other land-use activities in the watershed, and is probably continuing to adjust, seeking a new equilibrium. With an incised, widened, and encroached channel, the pre-dam channel-forming flows used for this evaluation may not be appropriate for Dry Creek in its new configuration. Flows in Dry Creek may currently be sufficiently high to mobilize the bed and thus avoid adverse effects associated with sedimentation of the streambed. It is not clear whether a small increase in the frequency of flows of 2,500 cfs would produce a change in channel geomorphology over baseline conditions.

A.3.2.2.2 Scour of Spawning Gravels

Releases made to increase the frequency of channel maintenance flows are intended to flush fine sediments from the streambed so that spawning and rearing habitats are maintained in good condition to permit successful reproduction. An increase in the frequency of channel maintenance flows to improve channel geomorphology could be offset by a negative effect: a loss of spawning gravels. This is of particular concern for coho salmon because they typically use smaller-sized gravels, which are more likely to be scoured.

Coho Salmon

Implementation of this action would cause more scour and result in a maximum annual score of 3 or 2 for coho salmon, depending on the timing of the flushing flow (Table A-6). Flows that occur later in the spawning period are more damaging as reflected in the score of 2. More frequent releases at this level would result in lower scores overall.

Under baseline conditions (Table A-1), scores of 4 occur 5.6 percent of the time, and scores of 5 occur 13.9 percent of the time. Therefore, potential benefits to channel geomorphology would be offset by poorer conditions for coho salmon reproduction.

Table A-6 Coho Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Flushing Flows

Flow Range	Coho Salmon Dec.1-Jan.31 (before spawning is over)	Coho Salmon Feb. 1-Feb. 28 (incubation)	Score
<800 cfs	5	5	
>800-1,400 cfs	4	3	
>1,400-3,000 cfs	3	2	X
>3,000-8,700 cfs	2	1	

Steelhead

Under this action, this flow regime would result in a maximum annual score of 4 or 3, depending on the timing of the flushing flow (Table A-7). More frequent releases at this level would result in lower scores.

Under baseline conditions (Table A-1), scores of 4 occur 16.7 percent of the time, and scores of 5 occur 22.2 percent of the time. Therefore, potential benefits to channel geomorphology would be offset by somewhat poorer, but still acceptable conditions for steelhead reproduction.

Table A-7 Steelhead Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Channel Flushing Flows

Flow Range	Steelhead Dec. 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)	Score
<1,300 cfs	5	5	
>1,300-2,600 cfs	4	3	X
>2,600-5,500 cfs	3	2	
>5,500-12,000 cfs	2	1	

Chinook Salmon

Because Chinook salmon spawning gravels are larger than those used by coho salmon or steelhead, scores of up to 5 can be maintained under this action (Table A-8). Flows of less than 3,000 cfs do not appreciably scour Chinook salmon spawning gravels. Therefore, the resulting distribution of scores would be similar to baseline conditions (Table A-1).

Table A-8 Chinook Salmon Scoring Criteria for Scour of Spawning Gravels in Dry Creek with Flushing Flows

Flow Range	Chinook Salmon Nov. 1-Jan. 31 (before spawning is over)	Chinook Salmon Feb. 1-Mar. 31 (incubation)	Score
<3,000 cfs	5	5	X
>3,000-6,000 cfs	4	3	
>6,000-9,000 cfs	3	2	
>9,000-15,000 cfs	2	1	

Summary

Baseline flood control operations were evaluated for scour of spawning gravels in Dry Creek for all three species (Table A-1). Steelhead gravels scored a 3 or above in 72 percent of the years. Scores were highest for Chinook salmon gravels, with 86 percent of the years scoring a 3 or greater and 47 percent of the years scoring a 5, indicating little potential for scour. In contrast, coho salmon spawning gravels faired poorly, with 36 percent of years scored 3 or better. Coho salmon spawn in the smaller gravel sizes between November and January. As a result, coho salmon have considerable exposure to high flow and are more vulnerable to scour due to the smaller size of their spawning gravels as indicated by 42 percent of the years scoring a 1.

Considering that the streambed should be periodically entrained to flush and transport fine sediments and thereby maintain good-quality spawning gravels, the scores for baseline probably indicate a reasonably good balance between streambed-mobilization and spawning gravel stability for successful reproduction of Chinook salmon, and an acceptable balance for steelhead. Coho salmon spawning gravels in Dry Creek could be scoured frequently and could result in low incubation success. The channel downstream of Warm Springs Dam has adjusted in response to flow regulation and other land-use activities in the watershed, and the present channel configuration of Dry Creek is likely to contribute to scour of coho salmon spawning gravels. The narrowing and straightening of the channel from riparian encroachment and channel down-cutting may exacerbate the circumstances.

An annual occurrence of flows of 1,500 to 2,500 cfs could increase the overall potential for scour of coho salmon and steelhead gravels. Due to the larger size of Chinook salmon spawning gravels, this action would not lead to increased scour of Chinook salmon gravels over baseline conditions. Potential benefits to channel geomorphic conditions may be offset somewhat by an increase in the frequency of scour of spawning gravels for coho salmon and steelhead.

A.3.2.2.3 Bank Erosion

Sustained releases of flood flows of greater than 2,500 cfs have the potential to cause streambank instability in Dry Creek. This action would not increase the frequency of successive days with flows exceeding 2,500 cfs. Therefore, the potential for bank erosion would not increase over baseline conditions.

A summary of Dry Creek bank erosion scores is presented for two locations (immediately below Warm Springs Dam and Near Geyserville) in Table A-9. The Near Geyserville location is below the Pena Creek confluence, which represents the most significant tributary input on the Dry Creek system.

Table A-9 Percentage of Years with Bank Erosion Scores for Dry Creek

	Score				
Location	**5**	**4**	**3**	**2**	**1**
Below Warm Springs Dam	58	8	8	3	11
Near Geyserville (below Pena Creek)	50	17	6	0	28

Near Geyserville about half of the years in the period of record analyzed received a score of 5, indicating that flows exceeded 2,500 cfs in no more than 3 days per year. Similarly, below Warm Springs Dam, more than one-half of the years received a score of 5.

Near Geyserville 10 out of the 36 years in the period of record received a score of 1. Thus, flows exceeded 2,500 cfs more than 16 days in each of those 10 years, for approximately 28 percent of the time. This suggests that streamflow conditions are highly conducive to bank erosion near Geyserville. Inspection of the flow records indicates that in many years when the score is 1, there are at least 5 or more consecutive days with flows exceeding 2,500 cfs, indicating prolonged high-flow conditions. Bank erosion scores are relatively good immediately below Warm Springs Dam.

It is important to note that on many days when flows exceeded the erosion threshold at the Near Geyserville location, discharge from Warm Springs Dam was low. For example, inspection of the modeled flow records indicate that in water year 1983, there were 33 days when flows exceeded the 2,500 cfs erosion threshold Near Geyserville (Table A-2); but on 13 of those 33 days, the release from Warm Springs Dam was no greater than 120 cfs. Flood control operations are often timed so that reservoir outflows during prolonged peak streamflow conditions downstream are a relatively insignificant contributor to total flow and bank erosion.

Of the 318 days during the modeled period of record when flows exceeded the 2,500 cfs erosion threshold, there were 114 days (36 percent of the time) when natural flow accretion alone below Warm Springs Dam was greater than the 2,500 cfs erosion threshold. Flow releases were either very low or smaller than natural flow accretion below the dam so that the erosion threshold would have been exceeded regardless of flow releases from the dam. Therefore, the evaluation criteria may overstate the influence of flood control operations at Warm Springs Dam on downstream bank erosion. Regardless, the scoring results indicate that flood operations at Warm Springs Dam do not cause prolonged flows above the threshold that initiate streambank instability and erosion in most years.

A.3.2.3 OTHER CONSIDERATIONS

Ramping flows up to achieve the required 1,500 to 2,500 cfs for 1 day could be accomplished as part of normal flood control releases. Periodically, releases of up to 6,000 or 8,000 cfs may be required for flood control. The channel maintenance flow above the confluence with Pena Creek is estimated to be 5,000 cfs.

On Dry Creek, sustained flows above 2,500 cfs initiate bank erosion. However, a 1-day flow of 1,500 to 2,500 cfs is not likely to result in increased streambank erosion. However, this action has the potential to increase channel incision.

Providing increased or more frequent channel maintenance flows could require the acquisition of conservation easements along Dry Creek to provide a connected flood plain with improved riparian function. Purchase of conservation easements or rights-of-way to facilitate restoration of the riparian corridor is described in further detail in Section A.3.4.

A.3.3 RESTORATION OF THE OVERFLOW CHANNELS ON DRY CREEK

The objective of this action is to restore the high-flow channels on Dry Creek to provide additional flood capacity and reduce the potential for bank erosion, and to increase the channel complexity and improve habitat conditions for salmonids.

A.3.3.1 ACTION DESCRIPTION

This action would include selectively removing riparian vegetation from the flood (i.e., high-flow) channel of selected portions of Dry Creek, thereby removing obstructions to flow. Woody vegetation between the high-flow bank edge and the edge of the low-flow channel would be removed. A band of riparian vegetation along the low-flow channel would be left intact to provide shading. The width of the vegetation band would be determined on a reach-by-reach basis to ensure that sufficient vegetation is left to shade the low-flow channel and ensure stability of the vegetation. Site-specific conditions would be evaluated to ensure floodplain continuity and habitat connectivity.

The high-flow channels would carry water during flood flows. The channels would be recontoured, as necessary, to drain back to the main channel as flows recede. The slope and gradient of the high-flow channels would be adjusted to reduce the potential for young fish to become trapped or stranded when the channels dewater.

The construction of high-flow channels may require some additional site grading and bank contouring to reconnect the main and high-flow channels. This construction activity would take place during the low-flow period to minimize the opportunity for sediment to reach the active channel. Heavy equipment would be used following construction BMPs, which would reduce the risk to young fish and minimize habitat disruption. Periodic maintenance of high-flow channels may be required to prevent vegetation encroachment. Overflow channels may require more space along Dry Creek than is currently available and purchase of conservation easements may be required.

A.3.3.2 EFFECTS ON PROTECTED SPECIES

The main benefit of this action would be to increase the channel complexity in Dry Creek and improve habitat conditions for salmonids. The high-flow channels would reduce river stage and velocity during flood flows and could also reduce the amount of bank erosion occurring in Dry Creek. The channels could provide refuge habitat for young fish during flood flows. Even though the channels would be constructed to minimize the potential for young salmonids to become trapped or stranded, some fish could be trapped in isolated pools and later lost to predators or desiccation.

Criteria to assess the potential effects of this restoration action are provided in Table A-10. Based on the potentially high benefit to listed species, this action would receive a score of 4.

Table A-10 Biological Benefit Evaluation Criteria for Restoration Actions

Category Score	Evaluation Criteria Category	
5	Very high potential to benefit.	
4	High potential to benefit.	X
3	Moderate potential to benefit.	
2	No benefit and utilizes scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

Effects on listed species during the construction phase of this action would be minimized by performing these activities during low-flow conditions. Any site grading and bank contouring required to reconnect the main and high-flow channels would take place during the low-flow period to minimize the opportunity for sediment to reach the active channel. Heavy equipment would be used following construction BMPs, which would reduce the risk to young fish and minimize habitat disruption. Periodic maintenance of high-flow channels could be required to prevent vegetation encroachment. Vegetation maintenance and gravel-bar grading operations would follow the procedures described in Section A.3.4. Therefore, this action would receive a score of 5 for instream sediment control and for upslope sediment control (Table A-11). Since the project would be conducted in the dry part of the channel, it would receive a score of 4 relative to the opportunity for injury to protected species (Table A-12).

Table A-11 Sediment Containment Evaluation Criteria

Category Score	Evaluation Criteria Category	
	Component 1: Instream sediment control	
5	Project area does not require rerouting streamflow.	X
4	Clean bypass or similar method used.	
3	Effective instream sediment control (e.g., berm/fence).	
2	Limited sediment control.	
1	No instream sediment control.	

Table A-11 Sediment Containment Evaluation Criteria (Continued)

Category Score	Evaluation Criteria Category	
	Component 2: Upslope sediment control	
5	No upslope disturbance, or an increase in upslope stability.	X
4	Limited disturbance with effective erosion control measures.	
3	Moderate to high level of disturbance with effective erosion control measures.	
2	Action likely to result in increase in sediment input into stream.	
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.	

Table A-12 Opportunity for Injury Evaluation Criteria

Category Score	Evaluation Criteria Category	
5	Project area is not within flood plain or below maximum water surface elevation, and requires no isolation from flow.	
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern is not present.	X
3	Appropriate BMPs are applied; e.g., project area survey, escape, or rescue provided; project area isolated from flow (if appropriate).	
2	Limited ability to apply appropriate BMPs.	
1	Appropriate BMPs are not applied.	

A.3.3.3 Other Considerations

To fully implement this action, purchase of conservation easements and the establishment of riparian zones along the banks would be required (Section A.3.4) as the overflow channels may require more space than is currently available along Dry Creek.

A.3.4 Purchase Conservation Easements or Rights-Of-Way to Facilitate Restoration of the Riparian Corridor

The objective of this action is to expand the riparian zone along Dry Creek to provide long-term habitat benefits. It would enhance instream conditions and the quality and amount of fish habitat by providing a floodplain management zone capable of supporting riparian and floodplain ecological functions linked to in-channel habitat conditions. By allowing high-flow events to scour and deposit sediments, and to transport and deposit woody debris within an adequately broad riparian/floodplain zone, habitat for anadromous salmonids would be enhanced in terms of diversity and complexity.

A.3.4.1 Action Description

Procurement, from willing sellers, of an approximately 300-foot-wide easement along both banks would provide substantial opportunities for construction of a new floodplain surface. Options could include establishment of riparian buffer zones, development of conservation easements, and riparian planting programs. A component of this action would be landowner education and outreach.

A.3.4.2 Effects on Protected Species

In Dry Creek, channel incision and loss of functional floodplains have resulted in a relatively narrow and steep channel, often with precipitous banks. In reaches confined by bank protection efforts, the stream has little opportunity to meander and has decreased sinuosity. Flood control operations have greatly altered the frequency, timing, duration, and magnitude of high-flow events. Relatively stable summer flows, in concert with attenuated flood flows, have facilitated encroachment by willows and other riparian plants. Under the existing conditions, habitat in Dry Creek is characterized by low diversity and complexity.

Once a meandering stream, Dry Creek below Warm Springs Dam is now less sinuous, steeper, and narrower, and flows between steep banks often revetted with riprap or other erosion-resistant surfaces. Where bank vegetation has been reduced, flood events are more likely to accelerate changes in channel morphology such as widening or incision. Riparian vegetation, although abundant in many places, contributes little to habitat quality except by providing temperature control by shading the stream. The banks of Dry Creek are presently too steep to readily allow establishment of riparian vegetation. The banks would have to be graded to a shallower slope prior to planting vegetation. A more natural condition would incorporate a diversity of ages and species of riparian plants, including trees large enough to provide substantial instream benefits. As flood flows are again able to create a sinuous channel, a more complex mosaic of instream and riparian habitats would develop. Over time, trees maturing along the banks would fall into the stream channel at irregular intervals and locations, thereby helping to promote and maintain variation in stream morphology. In addition, this large woody debris would provide improved conditions for rearing by providing reduced flow velocities and cover for the fry and juvenile salmon and steelhead.

In Dry Creek, production of salmon and steelhead has in part been limited by the low quality and amount of spawning and rearing habitat. The quality and amount of habitat could be substantially enhanced by encouraging development of a healthy floodplain, riparian zone, and stream channel. Fish production for each of the listed salmonid species would be expected to increase in response to rehabilitation of the river corridor. Rearing lifestages would benefit substantially from increases in the availability of high-quality feeding stations adjacent to instream cover. Mortality associated with storm-flow events (e.g., flushing of redds or juveniles during peak flows) would decrease. Increased food production from the larger number and size of riffles found in a meandering channel would support larger populations of fry and juveniles. An enlarged riparian zone would likely also provide increased input of terrestrial invertebrates to the stream. Based on the potential to benefit salmonid habitat conditions, this action would receive a score of 4 (Table A-13).

Table A-13 Biological Benefit Evaluation Criteria for Restoration Actions

Category Score	Evaluation Criteria Category	
5	Very high potential to benefit.	
4	High potential to benefit.	X
3	Moderate potential to benefit.	
2	No benefit and utilizes scarce resources.	
1	Poorly planned or implemented, degrades habitat.	

A.3.4.3 OTHER CONSIDERATIONS

Expanding the riparian management zone along Dry Creek through conservation agreements or rights-of-way has been investigated at least twice in the past; however, it has not been successful mainly due to lack of landowner participation. This action holds considerable long-term promise and should continue to be considered. Implementation would require willing landowner participation. Opportunistic purchase, given sufficient funds, of streamside property would allow gradual accumulation of suitable land for restoration.

The Mirabel inflatable dam on the Russian River upstream of the Mirabel area raises the water level in the river to increase recharge of the aquifer and to facilitate the diversion of water into the infiltration ponds. When inflated, the dam impounds water for approximately 3.2 miles (5.1 kilometers [km]) upstream, creating the Wohler Pool.

Recent SCWA and NOAA Fisheries studies have documented migration delays of smolts at the dam. Data suggest that steelhead smolt outmigration is delayed when the dam is inflated (Manning et al. 2001, Manning 2003), while Chinook salmon migration is not (Chase et al. 2002). From 2000 to 2002, radiotelemetry was used to evaluate steelhead migratory behavior, passage, and survival, using hatchery fish from DCFH. Results of the study are presented in Section 3 and Section 5. Findings suggest that delays in emigration under baseline operations are due to the inability of the smolts to pass the dam rather than to a decrease in current velocities within the impounded reach.

There is also a potential to strand fish if partial or full inflation or deflation of the dam causes flow recessions downstream or upstream of the dam, respectively. The Mirabel inflatable dam is generally inflated in the spring and lowered at the onset of winter rains. The dam may also be lowered to prevent damage in response to rising flows from late spring rains. Rare emergency situations may occur that necessitate deflating the dam during low-flow conditions. When the dam is inflated, flows downstream of the dam may be temporarily reduced until the water reaches the elevation of the bypass structures at the fish ladders. These flow recessions have the potential to dewater habitat and strand juvenile fish below the dam. If the dam is deflated during low-flow conditions, stage declines upstream of the dam have the potential to strand fish.

The following sections present two actions to minimize migration delays past the inflatable dam and reduce the risk of stranding young fish.

A.4.1 PARTIALLY LOWER THE INFLATABLE DAM ON A PERIODIC BASIS DURING THE OUTMIGRATION PERIOD

The objective of this action is to create flows over the dam to provide an additional passage route for juvenile salmonids over the dam. This action would reduce potential downstream migration delay through the Mirabel facilities and potential delay associated with passage through the impoundment.

A.4.1.1 ACTION DESCRIPTION

The Mirabel inflatable dam would be partially lowered for up to 48 hours at a time on a weekly to biweekly frequency through the end of June. This action would temporarily increase flows over the center of the dam and would serve to flush outmigrating salmonids from behind the dam and into the lower Russian River. The dam would be lowered approximately 6 feet, the maximum amount that would still allow continued flows through the bypass pipelines associated with the fish ladders.

A.4.1.2 Effects on Protected Species

As part of a 5-year monitoring program, SCWA used radiotelemetry to measure the length of time required for hatchery steelhead smolts to emigrate through the impounded reach of the river before and after inflation of the dam. Data were collected in the spring of 2000, 2001, and 2002. The data provide information about the average time elapsed from release to passage, the percentage of fish that passed the dam, the percentage of fish that were detected by the receiver but failed to pass the dam, smolt behavior in Wohler Pool, and the physiological stage of smoltification in released fish. Results indicate that the presence of the inflated dam reduces the rate of emigration. The data suggest that the delay in emigration is due to the inability of the smolts to pass over the dam or through the fish ladders rather than due to decreased current velocities within the impounded reach.

Lowering the dam would concentrate and increase the velocity of flow over the dam and provide a migration pathway for fish, thereby inducing the outmigrating salmonids to swim over the dam. By lowering the dam regularly during the migration period, outmigrating smolts would be flushed from behind the dam and the downstream migration delay through the Mirabel facilities could be reduced.

This action could potentially increase the potential for stranding of juveniles or fry upstream of the dam if the dam is lowered too rapidly, and downstream of the dam when the dam is inflated. Evaluation of the risk of stranding is based on three components: the rate of stage change during dam inflation/deflation; habitat features in the affected area, and the frequency of dam inflation/deflation. These components are evaluated for potential effects in the river upstream (dam deflation) and downstream (dam inflation) of the dam.

River stage upstream of the dam is regulated by the height of the dam. As the dam is lowered, the river stage would decline, which could potentially cause stranding of juveniles along the edges of the river. Dam deflation occurs at a rate of approximately 0.46 foot per hour, and would therefore receive a score of 3 for juveniles and 2 for fry (Table A-14 and A-15).

Table A-14 Ramping and Stage Change Evaluation Criteria for Juvenile and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Meets 0.16 feet per hour (ft/hr) maximum stage change.	
4	Meets 0.32 ft/hr maximum stage change.	
3	Meets 0.48 ft/hr maximum stage change.	Upstream (deflation), Downstream (inflation)
2	Meets 1.4 ft/hr maximum stage change.	
1	Greater than 1.4 ft/hr maximum stage change.	

Table A-15 Stage-Change Evaluation Scores for Dam Deflation and Inflation by Species for Fry

Category Score	Evaluation Categories	Current Operations Score*
5	Meet 0.08 ft/hr maximum stage change.	
4	Meet 0.16 ft/hr maximum stage change.	
3	Meet 0.32 ft/hr maximum stage change.	
2	Meet 0.48 ft/hr maximum stage change.	Upstream (deflation) and downstream (inflation)
1	Greater than 0.48 ft/hr maximum stage change.	

When the dam is inflated, it begins to impound water, and flow is reduced downstream. Water spills over the dam until it is about two-thirds inflated, then most of the flow passes through the ladders and associated bypass pipelines. Inflating the dam changes the water level downstream until stable flows through the ladders and associated bypass pipelines are established. Water surface elevations downstream of the dam were monitored during a dam inflation event on May 22, 2003. The largest stage changes occurred near the beginning of the dam inflation, but stage changes then stabilized at approximately 0.40 to 0.48 ft/hr. Because the dam would be only partially deflated, this stage change is evaluated for this action. This rate of stage change receives a score of 3 for juveniles and 2 for fry (Tables A-14 and A-15).

Habitat features in the channel also affect the potential for stranding salmonids. A low-gradient river with many side channels, potholes, low-gradient gravel bars, and an abundance of large substrates and aquatic vegetation has a greater incidence of stranding than a single-channel river with steep banks (Hunter 1992). Because few habitat features upstream of the dam would induce stranding, the score is 4 for fry, juvenile, and adult salmonids of all three species (Table A-16). Because there are riffles downstream of the dam, the risk for stranding is slightly higher than for the upstream reach. The score for effects of downstream habitat features on stranding during dam inflation is 3 (Table A-16).

Table A-16 Habitat/Flow Recession Interaction Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Upstream (deflation)
3	Some habitat features that induce stranding, but area affected is small (<30%).	Downstream (inflation)
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

The final component for evaluation is the frequency of dam inflation and deflation. This action would increase the frequency of raising and lowering of the dam during the smolt outmigration season from the time the dam is initially raised around April/May through June. The dam would be deflated between 6 and 12 times during this period, then inflated the same number of times. The increased number of fluctuations would increase the potential for juvenile fish to become stranded. Therefore, the effect of flow fluctuations is given a score of 3 (Table A-17).

Table A-17 Flow Reduction Frequency Evaluation Criteria for Juvenile and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Less than 2 fluctuations per year in critical habitat.	
4	Between 3 and 9 fluctuations per year in critical habitat.	
3	Between 10 and 29 fluctuations per year in critical habitat.	Upstream (deflation), Downstream (inflation)
2	Between 30 and 100 fluctuations per year in critical habitat.	
1	More than 100 fluctuations per year in critical habitat.	
0	Daily fluctuations in critical habitat.	

Overall, the risk of stranding during spring inflation and deflation is highest for fry. Small Chinook salmon that are migrating in the early spring may be at risk, but by mid-spring, when this action would be implemented, average Chinook salmon lengths are generally longer than 60 mm FL (NOAA Fisheries definition of fry-sized), which reduces the risk. Chinook salmon in the vicinity of the inflatable dam averaged approximately 35 to 40 mm FL during the first few weeks of their lives in 2002, then quickly grew to approximately 80 mm by mid-April (Chase et al. 2003). Data indicate that some steelhead smaller than 60 mm were present in early April of 1999, but that average sizes of steelhead were larger than 60 mm by the end of May, and greater than 80 mm by the end of June (Chase et al. 2000). The average size of steelhead YOY increased from 44 mm to 84 mm between April and June 2000. Steelhead YOY became abundant in mid-April 2002, at an average of approximately 40 mm FL. Coho salmon fry are likely to use tributary habitat rather than mainstem habitat and therefore have a very low risk level. Steelhead and coho salmon downstream migrants are present in the mainstem during the spring, but are much larger and therefore have a lower risk level than YOY.

Stage changes may result in flow recessions that strand fry or juveniles on riffles downstream of the dam. Riffles downstream of the dam tend to be short and shallow, and have sand/gravel substrate, which reduces the risk. However, flow fluctuations could occur up to 24 additional times. Although this action would decrease the potential for migration delays, this improvement may be offset somewhat by an increased risk of stranding juvenile fish, especially Chinook salmon and steelhead fry.

A.4.1.3 OTHER CONSIDERATIONS

This action would periodically lower the water surface elevation at the Mirabel and Wohler diversion facilities, and would reduce infiltration to the aquifer and the efficiency of the diversion facility. This would affect SCWA's ability to meet peak water demand during the spring and early summer months. Therefore, under *dry* year, or *dry spring* conditions, the frequency and duration of lowering the dam could be reduced or curtailed.

Raising and lowering the dam presents potential hazards to dam operators and recreational users. Therefore, periodic lowering and raising would need to be scheduled to minimize the potential for recreational users to encounter the dam during these periods; for example, scheduling this action to avoid weekends or holidays.

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The current flow regime in the Russian River and Dry Creek is determined by the requirements of State Water Resources Control Board (SWRCB) Decision 1610 (D1610), water supply needs, and flood control operations. A recent flow study conducted jointly by SCWA, USACE, NOAA Fisheries, and CDFG, determined the current flow regime was higher than optimal for the rearing lifestages of coho salmon, steelhead, and Chinook salmon (ENTRIX, Inc. 2003). Based upon this finding, SCWA has developed a suite of alternative flow proposals to improve conditions for salmonids, while continuing to meet the water supply needs of the region. The preferred Flow Proposal is described in Section 4.3, and evaluated in Section 5.3. In this section, the effects of the Flow Proposal on salmonids are compared with two alternative flow regimes considered for implementation by SCWA.

A.5.1 FLOW REGIME ALTERNATIVES

The alternative flow regimes that are evaluated in this section include:

- The Flow Proposal at 75 percent buildout (FP-75) with no additional measures.
- D1610 with a pipeline (D1610 pipeline) along Dry Creek under current and full buildout demand levels.

Buildout demand levels refer to the future demand for Russian River water at full buildout assuming construction of all Water Supply and Transmission System Project (WSTSP) facilities (see Section 3.3.2).

The actual water supply facilities and diversion from the Russian River, which SCWA's Board of Directors may approve in the future, may differ from those contemplated by the WSTSP. The inclusion of the WSTSP future water supply assumptions nevertheless provides an approximate model for analysis of effects to salmonids from future water supply development.

The first flow alternative, FP-75, represents the highest water supply demand that would be met under the proposed Flow Proposal before any "additional measures" to supplement water supply would be implemented. SCWA anticipates having additional measures online by the 50 percent buildout. Additional measures include an aquifer storage and recovery (ASR) system, a pipeline from Warm Springs Dam to the mouth of Dry Creek or the Wohler diversion facility, and the development of additional water storage facilities (see Section 4.3.2.4 for details). The FP-75 scenario represents the largest flows released into the Russian River and Dry Creek to ensure adequate water supplies to the Mirabel and Wohler diversions.

The second flow alternative, D1610 pipeline, has a flow regime similar to D1610, but includes a pipeline to reduce flows in Dry Creek. This would help provide better rearing conditions for salmonids in the 14-mile reach from Warm Spring Dam (upper Dry Creek) to the mouth of Dry Creek. With the pipeline in place, flows in Dry Creek would typically range from 50 to 70 cfs (the target in models run was 70 cfs) under current and buildout demand. Any additional flows needed to meet water demands would be conveyed through the pipeline.

Flows in the Upper and Middle Reach Russian River under D1610 pipeline would be the same as those under D1610, because the pipeline only effects flows in Dry Creek. However, the flow in the Russian River, between the mouth of Dry Creek and the Mirabel diversion facilities, could vary depending on the terminus of the pipeline. If the pipeline terminated at the mouth of Dry Creek, flows in the Russian River from the mouth of Dry Creek to Mirabel could be higher than if the pipeline terminated at Mirabel or at a treatment plant. Model simulations of D1610 and D1610 pipeline, however, yielded similar results in the Lower Russian River, suggesting that the addition of the pipeline in Dry Creek would have little effect on habitat conditions for salmonids in the mainstem.

A.5.2 MEDIAN FLOWS UNDER DIFFERENT MANAGEMENT ALTERNATIVES

This appendix compares the effects of the flow alternatives on habitat conditions for coho salmon, steelhead, and Chinook salmon. These effects are contrasted with those of the Flow Proposal and D1610 water management under current and buildout demand levels (except for FP-75 where only the effects under 75 percent buildout are examined).

Tables A-18 through A-24 show the predicted monthly flows that would result for the seven alternative management scenarios in the Russian River at Ukiah, Hopland, Cloverdale, Healdsburg, and the Hacienda Bridge, and in Dry Creek at its upper and lower end. Flows at each location are the expected median values for each month. Flow rates in the tables labeled *all* water supply conditions represented median monthly flows based on daily model predictions over the entire 90 year simulation period (1910 to 2000). Flow rates are expected to equal or exceed the value in these tables 50 percent of the time over the long term, independent of the variability in water supply conditions between years. Flow rates in the tables labeled *dry* water supply conditions, represented median monthly flows for only those months that are rated as *dry* (see Section 3.4.1). These values provide information on predicted flows during periods of drought and/or low precipitation.

In general, the model results for the Russian River show there is very little difference in median flows between the Flow Proposal and FP-75, and between D1610 and D1610 pipeline. In fact, flows provided by D1610 and D1610 pipeline are essentially identical throughout the mainstem, even in the Lower Russian River below the mouth of Dry Creek (Hacienda Bridge). Both D1610 water management scenarios at buildout tend to provide the highest flows during the summer rearing season (June to October). Under *all* water supply conditions median flows are typically 30 to 60 percent higher than the Flow Proposal and FP-75 management in the Upper Russian River, and as great as 220 percent higher in the Lower Russian River. Under *dry* water supply conditions, all flow alternatives provide similar flows in Middle and Upper mainstem, however, water management under the D1610 scenarios would still result in greater flows in the Lower Russian River (Table A-22).

During the rest of the year (November to May), flows in the Russian River are controlled more by natural runoff and storm events. Thus, there is no real effect of the different management alternatives on flow conditions in the mainstem during this period.

In Dry Creek, the addition of the pipeline results in lower flows throughout the year, especially during the rearing season (Table A-23 and A-24). The pipeline allows management to control flows in Dry Creek so that they generally do not exceed 70 cfs, which would provide good-to-optimal rearing conditions for all three salmonid species. Median flows under the Flow Proposal at buildout and FP-75 are expected to be about 20 to 40 percent higher than D1610 pipeline in July and August, but then decline during the rest of the year. The Flow Proposal at buildout and FP-75, however, still provide suitable flows for rearing. On the other hand, median flows for D1610 at buildout are generally too high for salmonids rearing in Dry Creek. Thus, if water management were to continue under current baseline practices, the building of the pipeline would be required to ensure good rearing flows.

In general, the two alternative water management scenarios evaluated here only have a direct effect on flow conditions in Dry Creek, relative to the water management scenarios evaluated in Section 5.3. In the Russian River, the median flows provided by FP-75 are similar to the Flow Proposal at buildout conditions, while the flows provided by D1610 and D1610 pipeline are essentially identical.

Table A-18 Median Monthly Flows for the Alternatives at Ukiah (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	744	928	516	604	290	187	163	160	143	127	174	387
D1610 (current)	736	927	516	602	304	235	261	231	179	173	167	348
D1610-pipeline (current)	736	927	516	602	304	235	261	231	179	173	167	348
Flow Proposal 75%	724	925	512	600	297	189	195	160	145	134	178	371
Flow Proposal (buildout)	726	913	512	599	298	191	205	160	146	137	177	371
D1610 (buildout)	705	925	514	599	306	242	273	240	185	177	173	340
D1610-pipeline (buildout)	705	925	514	599	306	242	273	240	185	177	173	340

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	169	594	268	266	224	205	185	152	145	95	105	170
D1610 (current)	148	570	275	238	173	176	177	119	114	106	113	153
D1610-pipeline (current)	148	570	275	238	173	176	177	119	114	106	113	153
Flow Proposal 75%	164	600	278	251	242	217	223	154	151	110	123	155
Flow Proposal (buildout)	174	583	283	230	245	222	236	155	154	117	120	160
D1610 (buildout)	149	534	279	231	194	195	195	129	123	109	110	143
D1610-pipeline (buildout)	149	534	279	231	194	195	195	129	123	109	110	143

Table A-19 Median Monthly Flows for the Alternatives at Hopland (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	859	1088	625	684	312	184	152	150	137	124	177	424
D1610 (current)	844	1095	624	683	323	233	250	222	174	170	167	389
D1610-pipeline (current)	844	1095	624	683	323	233	250	222	174	170	167	389
Flow Proposal 75%	836	1083	617	681	313	184	182	149	139	131	180	407
Flow Proposal (buildout)	838	1081	617	677	315	185	192	149	140	135	180	407
D1610 (buildout)	812	1081	617	678	326	237	259	229	179	174	176	385
D1610-pipeline (buildout)	812	1081	617	678	326	237	259	229	179	174	176	385

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	189	665	349	286	229	194	170	145	138	94	109	184
D1610 (current)	186	633	356	273	175	165	162	111	107	102	114	177
D1610-pipeline (current)	186	633	356	273	175	165	162	111	107	102	114	177
Flow Proposal 75%	189	669	363	273	239	203	203	144	142	110	121	179
Flow Proposal (buildout)	190	645	365	257	237	207	214	145	145	116	124	177
D1610 (buildout)	176	595	363	257	194	180	177	120	114	105	113	145
D1610-pipeline (buildout)	176	595	363	257	194	180	177	120	114	105	113	145

Table A-20 Median Monthly Flows for the Alternatives at Cloverdale (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	1084	1400	854	833	361	183	140	137	130	122	191	507
D1610 (current)	1084	1404	853	831	365	232	234	209	167	168	171	461
D1610-pipeline (current)	1084	1404	853	831	365	232	234	209	167	168	171	461
Flow Proposal 75%	1078	1388	852	828	357	181	167	134	130	129	189	485
Flow Proposal (buildout)	1075	1384	851	825	357	180	176	133	131	134	187	481
D1610 (buildout)	1046	1398	851	827	364	235	239	214	171	171	183	462
D1610-pipeline (buildout)	1046	1398	851	827	364	235	239	214	171	171	183	462

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	271	807	533	331	248	181	147	134	129	93	130	223
D1610 (current)	263	778	535	326	189	151	141	99	96	98	123	239
D1610-pipeline (current)	263	778	535	326	189	151	141	99	96	98	123	239
Flow Proposal 75%	270	816	540	308	256	183	176	131	131	108	131	200
Flow Proposal (buildout)	270	780	541	312	254	185	186	131	133	115	129	204
D1610 (buildout)	226	730	539	308	202	153	149	104	101	100	122	158
D1610-pipeline (buildout)	226	730	539	308	202	153	149	104	101	100	122	158

Table A-21 Median Monthly Flows for the Alternatives at Healdsburg (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	1663	2181	1420	1193	501	181	119	128	126	141	227	664
D1610 (current)	1632	2182	1418	1196	500	237	208	200	164	169	183	598
D1610-pipeline (current)	1632	2182	1418	1196	500	237	208	200	164	169	183	598
Flow Proposal 75%	1602	2148	1399	1180	484	178	143	122	125	130	201	617
Flow Proposal (buildout)	1591	2127	1383	1172	478	178	151	120	124	134	190	602
D1610 (buildout)	1580	2128	1387	1175	478	237	209	200	164	170	178	587
D1610-pipeline (buildout)	1580	2128	1387	1175	478	237	209	200	164	170	178	587

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	466	1210	875	442	286	149	103	127	123	93	130	276
D1610 (current)	440	1182	838	442	217	112	98	89	89	95	127	335
D1610-pipeline (current)	440	1182	838	442	217	112	98	89	89	95	127	335
Flow Proposal 75%	430	1188	816	397	282	147	130	120	123	106	131	219
Flow Proposal (buildout)	419	1170	847	379	289	147	138	119	124	112	130	215
D1610 (buildout)	392	1141	809	411	227	113	100	90	90	96	112	203
D1610-pipeline (buildout)	392	1141	809	411	227	113	100	90	90	96	112	203

Table A-22 Median Monthly Flows for the Alternatives at Hacienda Bridge (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	2692	3912	2677	1795	672	175	75	67	77	106	302	961
D1610 (current)	2595	3867	2656	1796	702	258	192	171	147	162	275	930
D1610-pipeline (current)	2595	3867	2656	1796	701	258	192	171	147	162	275	930
Flow Proposal 75%	2583	3842	2615	1748	606	154	71	53	51	69	248	888
Flow Proposal (buildout)	2577	3806	2577	1739	582	156	74	54	49	64	234	854
D1610 (buildout)	2482	3654	2543	1739	611	185	138	139	137	139	226	811
D1610-pipeline (buildout)	2482	3654	2543	1739	611	186	138	139	137	139	226	811

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	767	1930	1511	596	327	123	52	65	71	57	169	408
D1610 (current)	725	1824	1496	572	249	102	92	95	96	96	156	430
D1610-pipeline (current)	725	1824	1496	572	249	105	93	95	96	95	156	430
Flow Proposal 75%	699	1863	1460	536	268	104	52	49	49	50	138	316
Flow Proposal (buildout)	681	1779	1443	492	268	110	53	50	45	49	125	302
D1610 (buildout)	652	1733	1363	510	202	96	93	97	100	93	127	308
D1610-pipeline (buildout)	652	1733	1363	510	202	97	93	96	100	93	127	308

Table A-23 Median Monthly Flows for the Alternatives at in Upper Dry Creek near Warm Springs Dam (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	91	350	275	139	53	63	74	63	57	54	91	91
D1610 (current)	76	278	255	134	81	95	103	93	85	81	106	106
D1610-pipeline (current)	76	278	255	134	70	70	70	70	70	70	106	106
Flow Proposal 75%	91	313	265	139	56	71	90	82	66	55	91	91
Flow Proposal (buildout)	91	302	265	140	60	75	89	83	79	55	91	91
D1610 (buildout)	76	158	208	115	81	106	148	146	126	91	106	106
D1610-pipeline (buildout)	76	158	208	115	70	70	70	70	70	70	106	106

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	76	76	76	51	51	71	83	63	58	56	78	76
D1610 (current)	76	76	76	26	26	88	129	127	117	91	76	76
D1610-pipeline (current)	76	76	76	26	26	70	70	70	70	70	76	76
Flow Proposal 75%	76	76	76	51	54	80	105	83	68	61	78	76
Flow Proposal (buildout)	76	76	76	51	56	83	101	83	82	65	78	76
D1610 (buildout)	76	76	76	26	26	172	236	217	171	124	82	76
D1610-pipeline (buildout)	76	76	76	26	26	70	70	70	70	70	82	76

Table A-24 Median Monthly Flows for the Alternatives at in Lower Dry Creek (cfs)

All Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	235	562	393	196	64	57	61	56	55	55	96	122
D1610 (current)	200	482	368	196	92	87	89	87	84	83	111	135
D1610-pipeline (current)	200	482	368	196	82	62	56	64	68	70	111	137
Flow Proposal 75%	230	518	388	197	68	60	72	71	61	55	96	122
Flow Proposal (buildout)	230	513	382	197	73	61	68	71	71	55	96	123
D1610 (buildout)	195	382	328	184	94	97	126	132	119	94	112	139
D1610-pipeline (buildout)	195	382	328	184	82	56	48	56	61	70	112	139

Dry Water Supply Conditions												
	Jan	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Dec**
Flow Proposal (current)	110	150	148	71	58	60	69	57	55	56	80	96
D1610 (current)	110	150	146	53	38	77	114	121	115	91	79	96
D1610-pipeline (current)	110	150	146	53	37	55	55	63	68	69	79	96
Flow Proposal 75%	110	150	148	72	61	65	85	71	63	62	80	97
Flow Proposal (buildout)	110	150	150	72	63	66	78	70	73	65	80	97
D1610 (buildout)	110	144	144	56	48	153	213	203	162	125	97	114
D1610-pipeline (buildout)	110	144	144	56	48	51	47	55	61	70	97	114

A.5.3 FLOW-RELATED HABITAT

In this section the effects of the various flow regimes (D1610, D1610 pipeline, Flow Proposal and FP-75) on daily flow and temperature conditions for listed salmonids are evaluated for current and buildout demand. Only the results from Dry Creek are discussed in detail, as this is the only reach where the alternative flow regimes provided any significant difference to the water management scenarios analyzed in Section 5.3. Flow and temperature results for the Russian River are discussed briefly at the end of this section.

The distribution of daily flow conditions for the different management scenarios are shown using pie charts. The pie charts give the proportion of daily flow and temperature values, over the 90 year simulation period, that correspond to the habitat criteria values for salmonids given in Appendix C. Scores for each life stage range from 0 to 5, with 0 representing conditions that may cause year-class failure, and 5 representing optimal conditions. Scores of 3 or better are considered to provide good conditions for the particular life-history stage, whereas scores of 2 or less represent marginal to poor conditions. DO concentrations were also modeled, and are predicted to be favorable for salmonids under all flow alternatives and are not discussed further.

A.5.3.1 COHO SALMON

Coho salmon utilize tributary habitat for spawning and rearing, and use the Lower Russian River for passage to natal streams. In Dry Creek, coho salmon abundance is very low, however, there is a potential for all life-stages to utilize this reach, should populations begin to recover. Therefore, the effects of the water management scenarios on flow and temperature conditions are evaluated for all coho salmon life history stages.

Flow

Figures A-1 to A-8, provided at the end of this section, show the effects of the different water management scenarios on flow conditions for coho salmon in Dry Creek. In general, the Flow Proposal, FP-75, and D1610 pipeline provide the best overall rearing flows. Under *dry* water conditions, the Flow Proposal at current water demand levels is predicted to provide the best rearing conditions, with good habitat flows occurring about 98 percent of the time. The Flow Proposal at buildout and the FP-75 provide good rearing conditions about 94 percent of the time while D1610 pipeline provides good conditions about 80 percent of the time. Under *all* water supply conditions, there is very little difference between the Flow Proposal, FP-75 and D1610 pipeline. All three of these management scenarios are predicted to provide better rearing flows than baseline management (D1610), especially as water demand increases.

In terms of upstream migration, spawning and incubation, there is very little significant different between any of the water management alternatives. Under all water supply conditions, the Flow Proposal and FP-75 provide a higher frequency of excellent-to-optimal flows for upstream migration and spawning conditions (scores ≥ 4). However, all management scenarios provide a similar proportion of good habitat flows for all three life history stages (Scores ≥ 3). Under *dry* water supply conditions, D1610 and D1610 pipeline provide a greater proportion of excellent-to-optimal flows for upstream migration, but all the alternatives provide a similar proportion of good migration flows.

Given that one of the goals of water management in Dry Creek is to improve rearing conditions for coho salmon, the model results indicate that the Flow Proposal, FP-75 and D1610 pipeline are all superior to current baseline management. The model also predicts that the Flow Proposal and FP-75 scenarios would provide slightly better rearing flows for coho salmon as water demand increases towards buildout levels. Since the Flow Proposal includes additional measures, but not necessarily the pipeline (Section 4.3) while FP-75 does not, this result suggests the flow regime developed for these management scenarios is the most important factor for improving rearing conditions in Dry Creek.

Temperature

Figures A-9 to A-16 show the effects of the different water management scenarios on temperature conditions for coho salmon in Dry Creek. Temperatures in Upper Dry Creek are predicted to be optimal for rearing under all management scenarios, while in Lower Dry Creek temperatures are generally too warm. Rearing temperatures are expected to improve slightly under D1610 management at buildout demand; however, the proportion of flows providing good rearing temperatures is only about 20 and 35 percent for *all* and *dry* water supply conditions, respectively. Given that juvenile coho salmon would probably swim upstream during the summer (i.e., down the temperature gradient), the effect of the difference between the water management regimes on juvenile survival (in terms of temperature) is likely insignificant.

During the upstream migration, spawning, and incubation periods, temperatures are predicted to be good-to-optimal for all management scenarios, under *all* and *dry* water supply conditions.

A.5.3.2 STEELHEAD

Steelhead use habitat throughout the Russian River watershed. The Lower Russian River is predominantly a migration corridor that allows adults to reach spawning in rearing habitat in the Middle and Upper Russian River and in Dry Creek. Steelhead populations are currently present throughout Dry Creek and in some of its tributaries.

Flow

Figures A-17 to A-24 show the effects of the different flow regimes on flow conditions for steelhead in Dry Creek. Like coho salmon, the biggest difference between the management scenarios is for juvenile rearing. The Flow Proposal and D1610 pipeline both provide better rearing flows than D1610 given current water demand levels. The D1610 pipeline provides the highest percentage of good to optimal flows in Upper Dry Creek (95 percent), while the Flow Proposal and D1610 pipeline provide good-to-optimal rearing flows about 88 percent of the time in Lower Dry Creek.

At buildout demand levels, the D1610 pipeline scenario is predicted to provide similar rearing conditions to those provided at current demand levels. The Flow Proposal at buildout demand would provide similar flow conditions to FP-75, with good-to-optimal rearing conditions occurring about 70 and 80 percent of the time in Upper and Lower Dry Creek respectively. The frequency distribution for daily flows under the Flow Proposal, FP-75 and D1610 pipeline management are similar for *all* and *dry* water supply conditions.

The frequency of good-to-optimal flows for upstream migration is similar among the water management scenarios. Under *all* water supply conditions, however, the frequency of excellent-to-optimal flows (scores ≥ 4) in Upper Dry Creek is much higher under the Flow Proposal and FP-75 management. In general, all of the proposed flow regimes should provide adequate flows for adult migration of steelhead throughout Dry Creek.

Spawning conditions under *all* water supply conditions are similar for all management scenarios; however, under *dry* conditions the Flow Proposal and FP-75 would provide the highest frequency of suitable flows in Upper Dry Creek. In general, these flow regimes supply good-to-optimal flows 85 percent of the time compared to 70 percent for D1610 and D1610 pipeline. In Lower Dry Creek, there is no significant difference in the quality of spawning flows between the different management scenarios.

Conditions for steelhead incubation are predicted to be best under the D1610 and D1610 pipeline scenarios for water management. Under *all* water supply conditions, these flow regimes would provide good-to-optimal flows in Upper Dry Creek about 65 percent of the time compared to 30 percent for the Flow Proposal and FP-75. This result is primarily due to the higher flows delivered by D1610 and D1610 pipeline during May and June in Upper Dry Creek, which would help ensure adequate delivery of oxygen to redds during embryo maturation. Under *dry* water supply conditions, all water management scenarios would provide similar flows for incubation, with good-to-optimal flows conditions occurring about 85 and 45 percent of the time in Upper and Lower Dry Creek respectively.

Given that rearing is likely the limiting life stage for steelhead in Dry Creek, all of the proposed management alternatives should improve flow conditions relative to current baseline water management (D1610). The D1610 and D1610 pipeline flow regimes would provide better conditions for incubation in Upper Dry Creek; however, the Flow Proposal and FP-75 would likely provide enough suitable incubation flows to ensure egg-to-fry survival rates remain high. Thus, the Flow Proposal and FP-75 are likely to result in the greatest increase in overall steelhead abundance (by increasing juvenile survival rates).

Temperature

Figures A-25 to A-32 show the effects of the different water management scenarios on temperature conditions for steelhead in Dry Creek. In general, all of the flow regimes provide similar conditions for steelhead during all life history stages. For the most part, temperature for rearing and upstream migration would always be suitable. Temperatures for spawning in Upper Dry Creek are always suitable, while in Lower Dry Creek they are marginal-to-poor about 5 to 15 percent of the time, under *all* and dry water supply conditions respectively. Temperatures for incubation are the least suitable; however, even in Lower Dry Creek the frequency of good-to-excellent temperature conditions during the incubation period is about 65 to 70 percent.

Overall, temperature is not expected to be a problem for steelhead in Dry Creek under any of the flow scenarios.

A.5.3.3 CHINOOK SALMON

Chinook salmon spawn primarily in the mainstem of the Middle and Upper Russian River and in Dry Creek. Juveniles generally rear in the mainstem channels from February through May, and migrate to the ocean no later than the end of June.

Flow

Figures A-33 to A-40 shows the effects of the different water management scenarios on flow conditions for Chinook salmon in Dry Creek. Under current water demand levels, the Flow Proposal, D1610 and D1610 pipeline would provide a similar frequency of good rearing flows for Chinook salmon. The Flow Proposal would provide a much higher frequency of excellent-to-optimal flows under *dry* water supply conditions, but in general, the difference between the flow regimes is minimal. As water demand increases, the Flow Proposal, FP-75 and D1610 pipeline would the best rearing flows under *all* water supply conditions, while the Flow Proposal and FP-75 would provide better flows than D1610 pipeline under *dry* water supply conditions. Thus, all three proposed flow regimes should improve rearing conditions at buildout demand relative to baseline, with the greatest improvements associated with the Flow Proposal management scenario.

The only other life history stage where the flow regimes potentially differ in their effect on Chinook salmon is upstream migration. In general, D1610 and D1610 pipeline are predicted to provide a slightly higher frequency of good to optimal flows than FP-75 and the Flow Proposal under current and buildout demand level. All of the water management scenarios, however, are predict to provide suitable flows at least 85 percent of the time and should not impede fish passage.

Temperature

Figures A-41 to A-48 shows the effects of the different water management scenarios on temperature conditions for Chinook salmon in Dry Creek. All of the flow regimes produce good-to-optimal conditions for all life history stages close to 100 percent of the time. The D1610 pipeline water management scenario is predicted to provide poor upstream migration flows about 5 to 10 percent of the time; however, this is unlikely to have much of an effect on migration success. In general, temperature is not a problem for Chinook salmon in Dry Creek during their entire lifecycle.

A.5.3.3.1 Russian River

Figures A-49 to A-84 show the effects of the different management scenarios on listed salmonids in the Upper (Ukiah and Hopland) and Middle (Cloverdale and Healdsburg) Russian River. Flow and temperature conditions in the Lower Russian River are essentially the same as those at Healdsburg. Since coho salmon only use the Russian River mainstem as a migration corridor to reach the tributaries (including Dry Creek) only the scores for upstream migration are shown. In general, there is very little difference between the two alternative scenarios (FP-75 and D1610 pipeline) relative to the Flow Proposal and D1610, except for upstream migration of Chinook salmon.

Flows under the Flow Proposal (including FP-75) would be managed so that the sandbar at the mouth of the Estuary remains closed until mid-October or the first storm event (see Section 4.3). Thus, adult Chinook salmon are prohibited from entering the Russian River during August and September. Because flows tend to be too low and water temperatures too warm and during this period, the Flow Proposal and FP-75 would improve conditions for upstream migration in the Russian River (Figure A-70 and A-78). By managing the Estuary as a closed system, the Flow Proposal and FP-75 would provide better flow and temperature conditions for upstream migration than the alternative flow regime, D1610 pipeline.

A.5.4 SUMMARY

The Flow Proposal, FP-75, and D1610 pipeline management alternatives would all provide better rearing conditions for salmonids in Dry Creek than D1610. Given that rearing habitat is likely a limiting factor for salmonids in the Russian River (especially for coho salmon and steelhead), all of these water management scenarios would improve conditions relative to baseline. By providing more suitable rearing habitat, they should also help increase the abundance of naturally spawning salmon in the Russian River Basin.

The D1610 pipeline provides slightly better rearing conditions for steelhead than either the Flow Proposal (especially at buildout) or FP-75. The addition of the pipeline allows water management to provide stable flows around 70 cfs during most of the rearing period. Under the Flow Proposal and FP-75 management, flows tend to be higher and more variable, which could occasionally cause juvenile steelhead (who often feed in riffles and runs) to get washed downstream. Overall, however, such events should be rare.

In the Russian River, the Flow Proposal (and FP-75) would provide slightly better conditions for Chinook salmon upstream migration, due to managing the Estuary as a closed system. By keeping returning adults out of the Russian River until the first storm event or mid-October, there is less chance they would be subjected to stressful temperatures during upstream migration. This should help increase the number of Chinook salmon that successfully spawn, and thus boost reproduction rates.

In general, water temperatures are expected to be highly suitable for all salmonid lifestages, under all three proposed flow regimes. Temperature is still expected to be a problem for rearing coho salmon in lower Dry Creek, but would be suitable in Upper Dry Creek. This should not be much of a problem given that the flow regimes would provide excellent flows for juvenile rearing, which should help increase overall abundance of coho salmon once they re-establish populations in the upper reaches.

Overall, the two alternative regimes analyzed here should provide similar beneficial conditions for salmonids as the Flow Proposal. While D1610 pipeline is predicted to be slightly more beneficial for steelhead rearing, the Flow Proposal is expected to provide the more beneficial conditions for Chinook salmon upstream migration. In terms of other life history stages, the difference between the effects of the flow alternatives on salmonids is small (and probably insignificant).

FIGURES SHOWING
DISTRIBUTION OF FLOWS AND TEMPERATURE SCORES
FOR DIFFERENT FLOWS
IN THE RUSSIAN RIVER AND DRY CREEK

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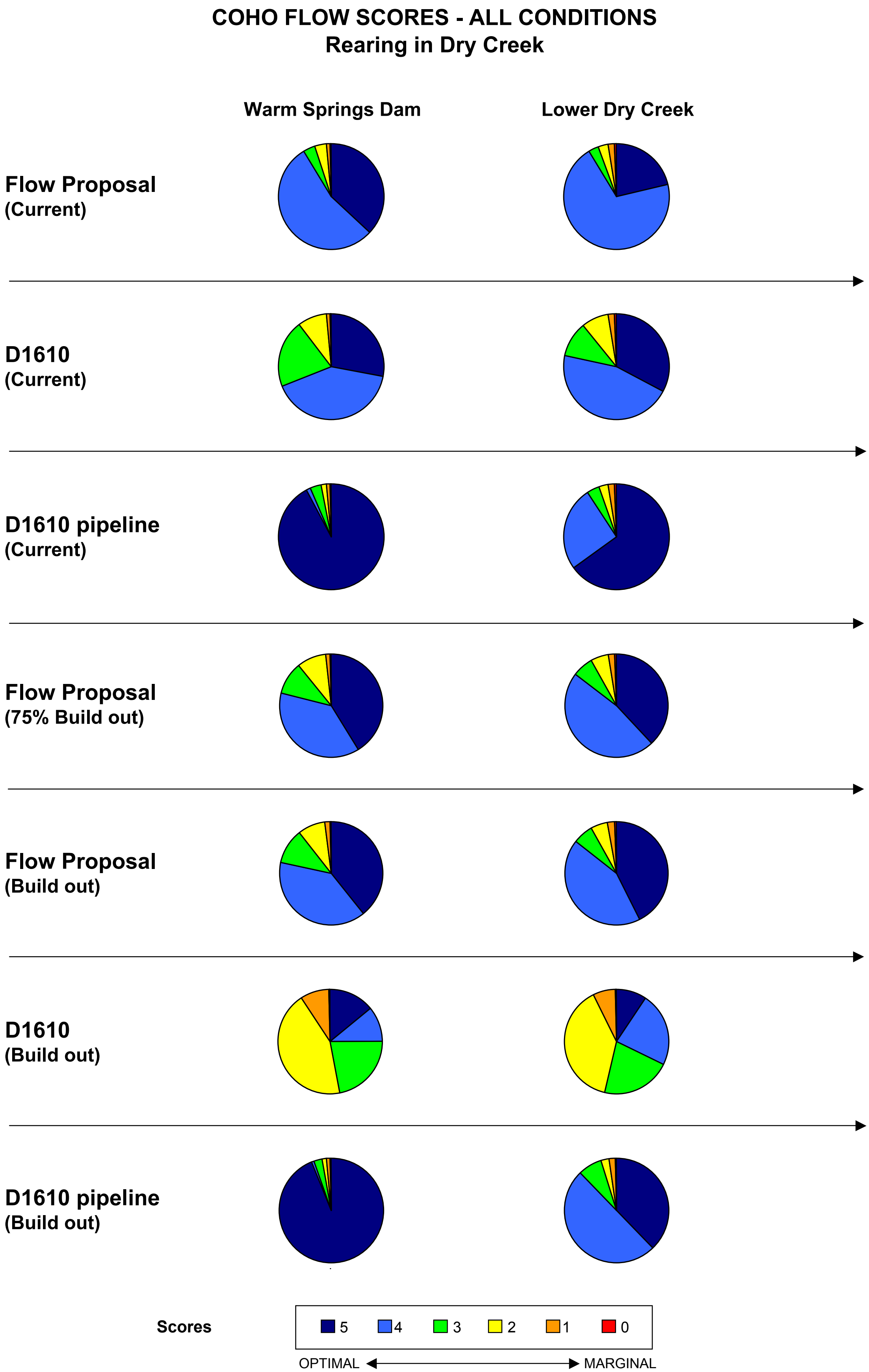

Figure A-1 Coho Rearing Flow Scores for All Water Supply Conditions in Dry Creek

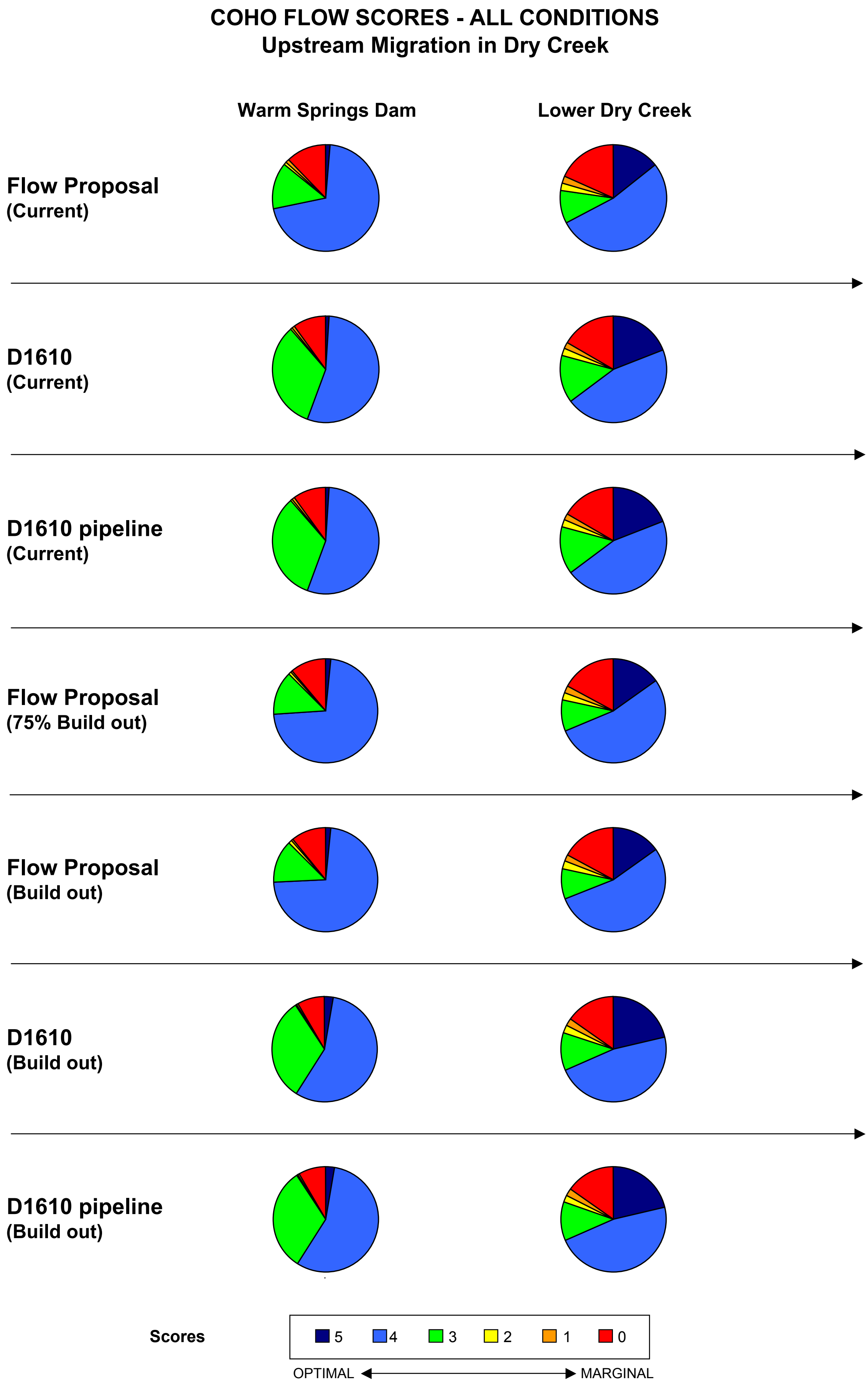

Figure A-2 Coho Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

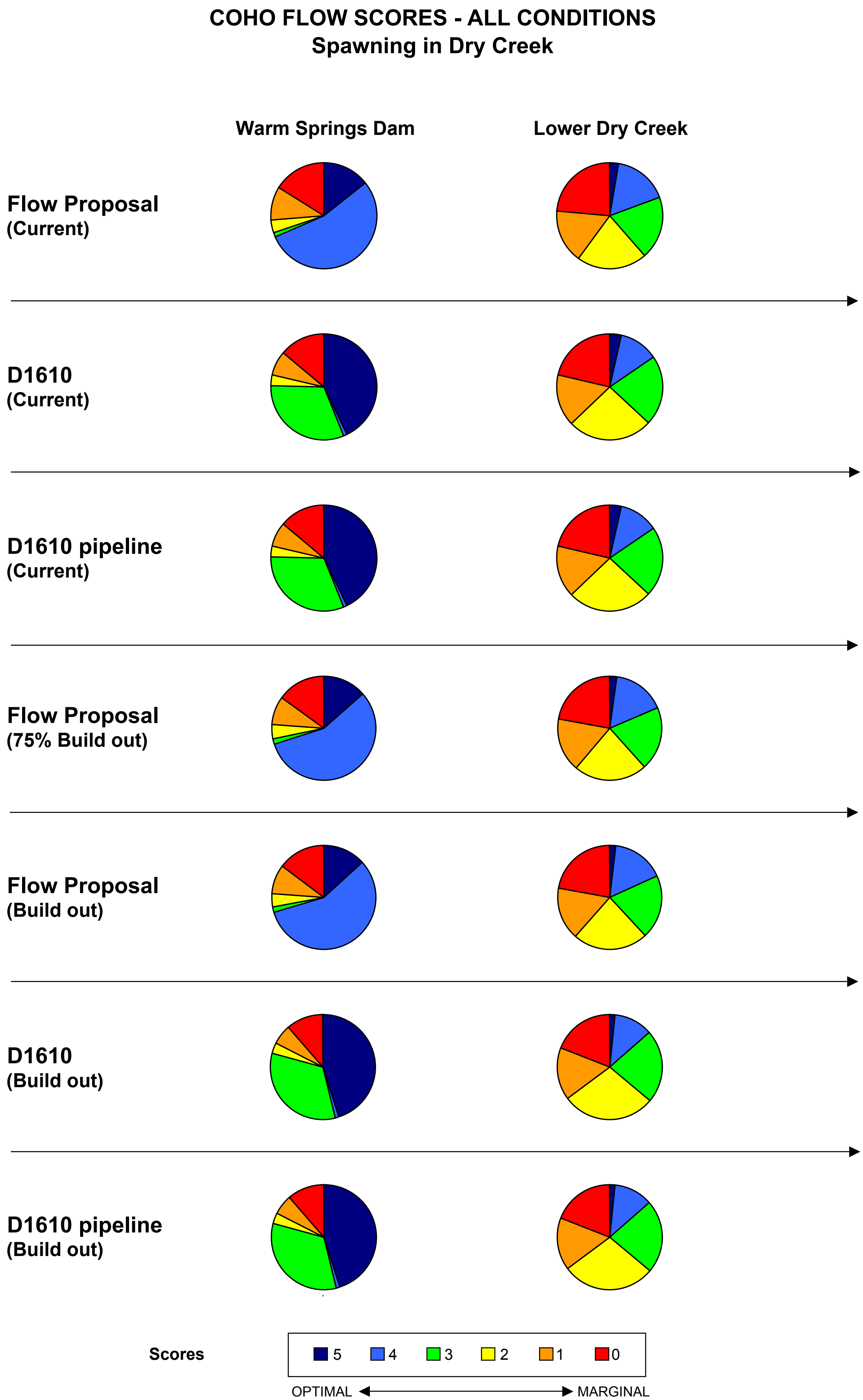

Figure A-3 Coho Spawning Flow Scores for All Water Supply Conditions in Dry Creek

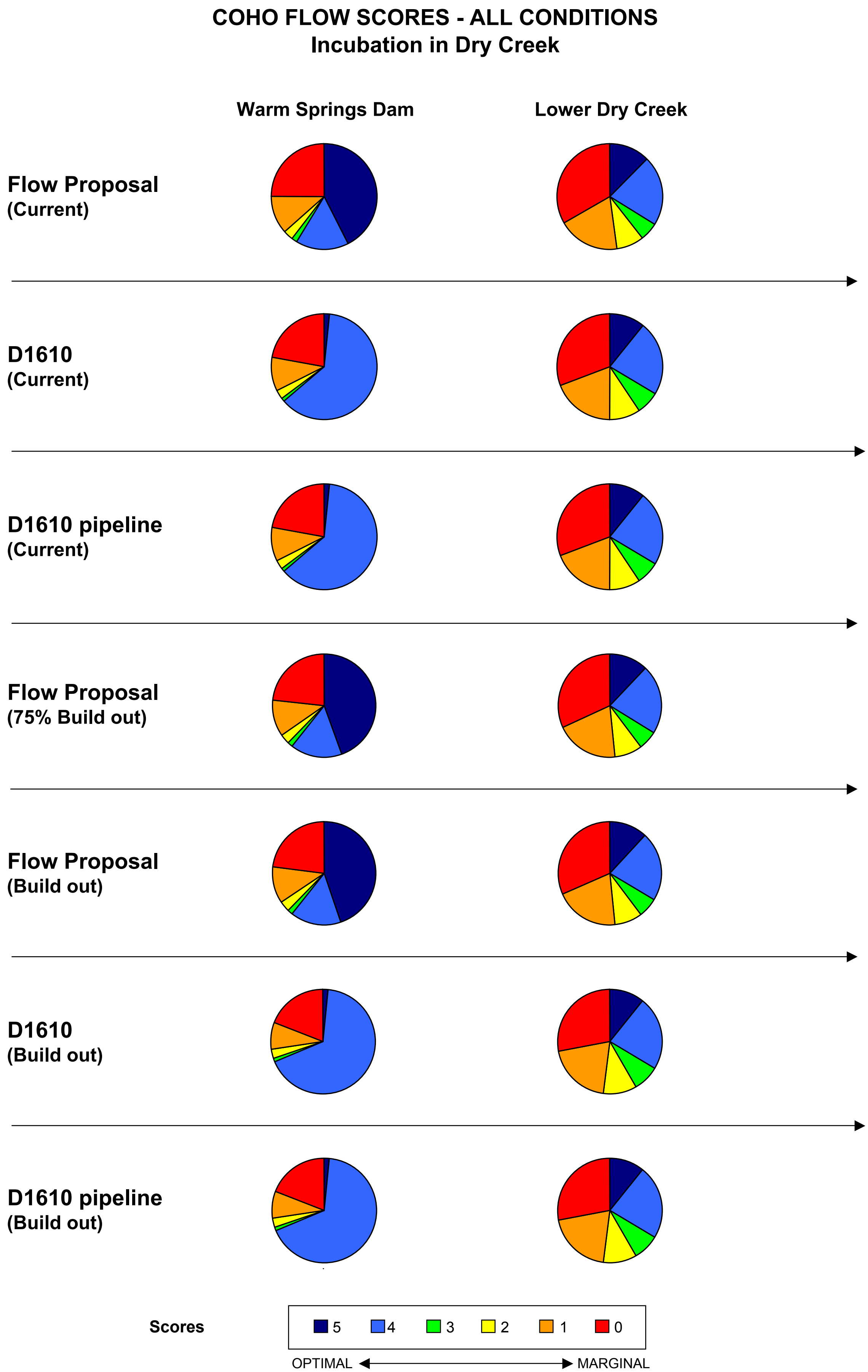

Figure A-4 Coho Incubation Flow Scores for All Water Supply Conditions in Dry Creek

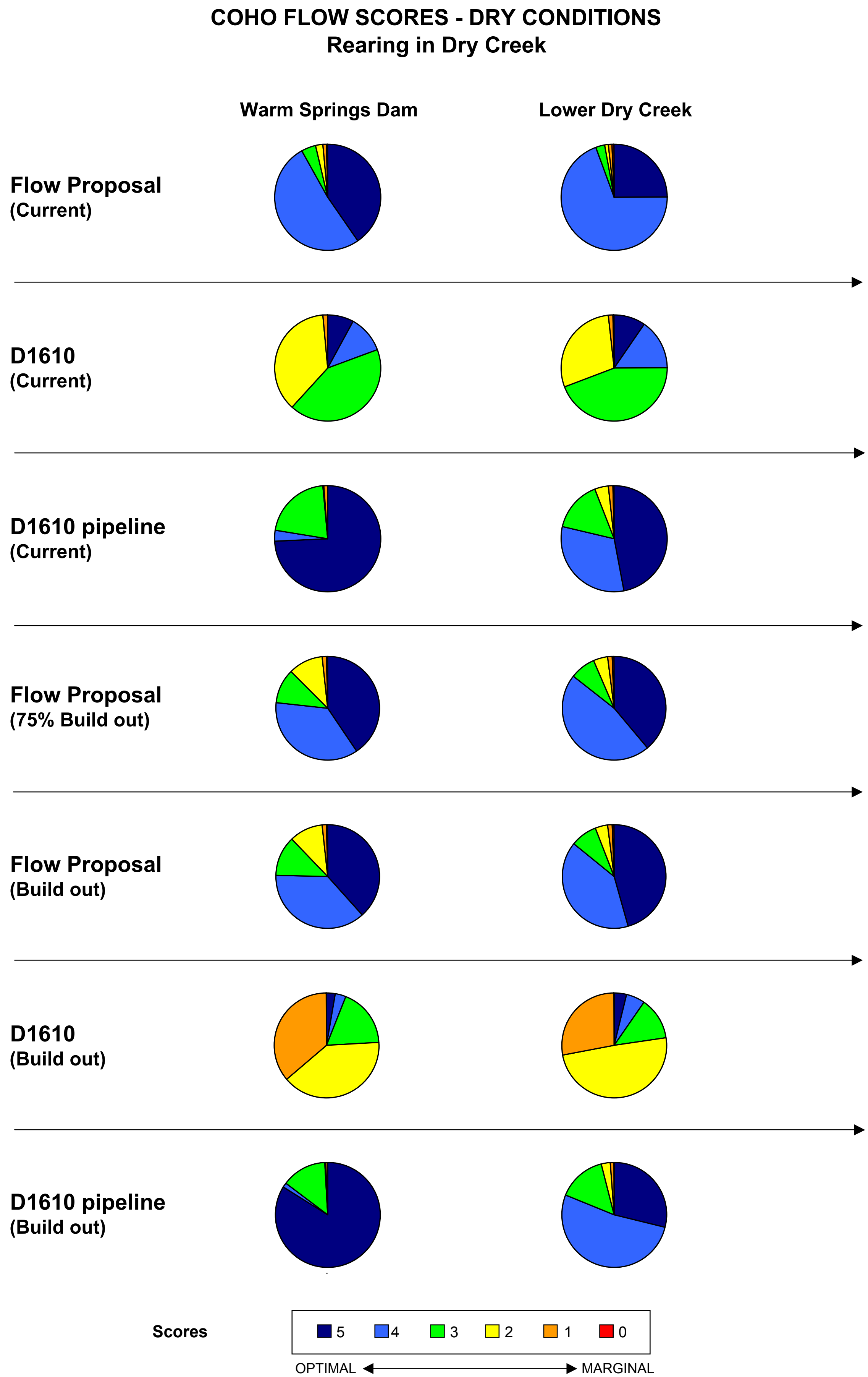

Figure A-5 Coho Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

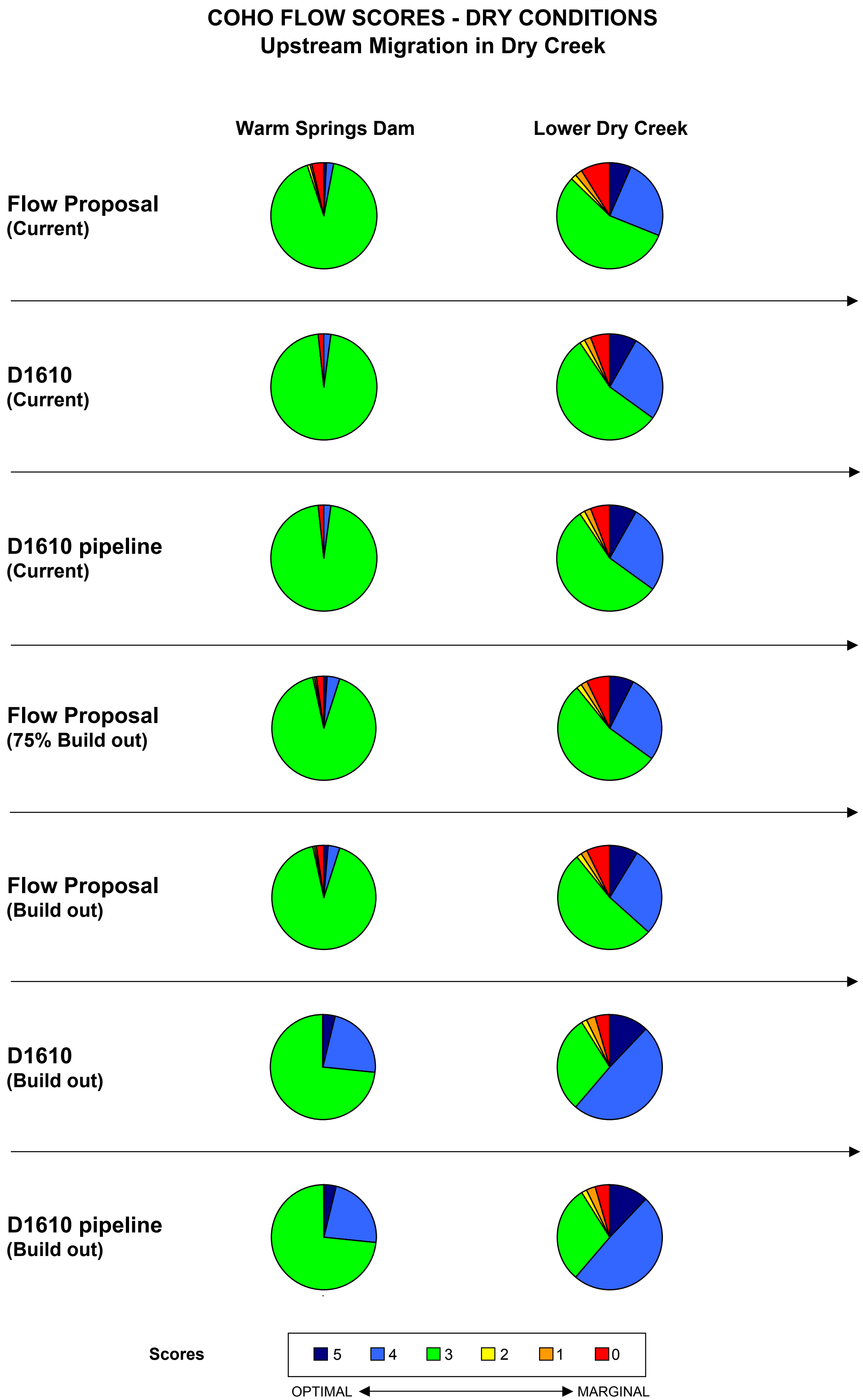

Figure A-6 Coho Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

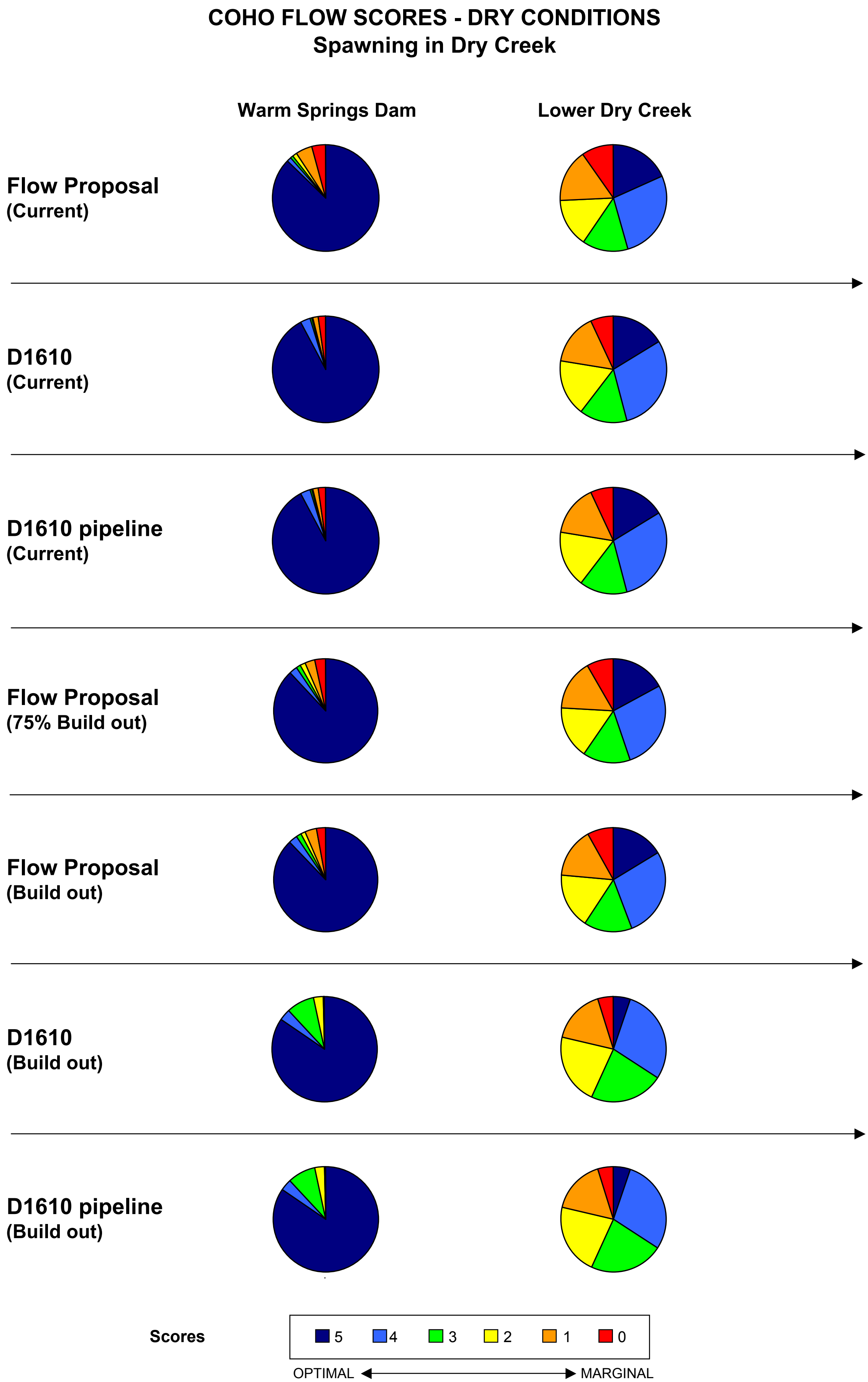

Figure A-7 Coho Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

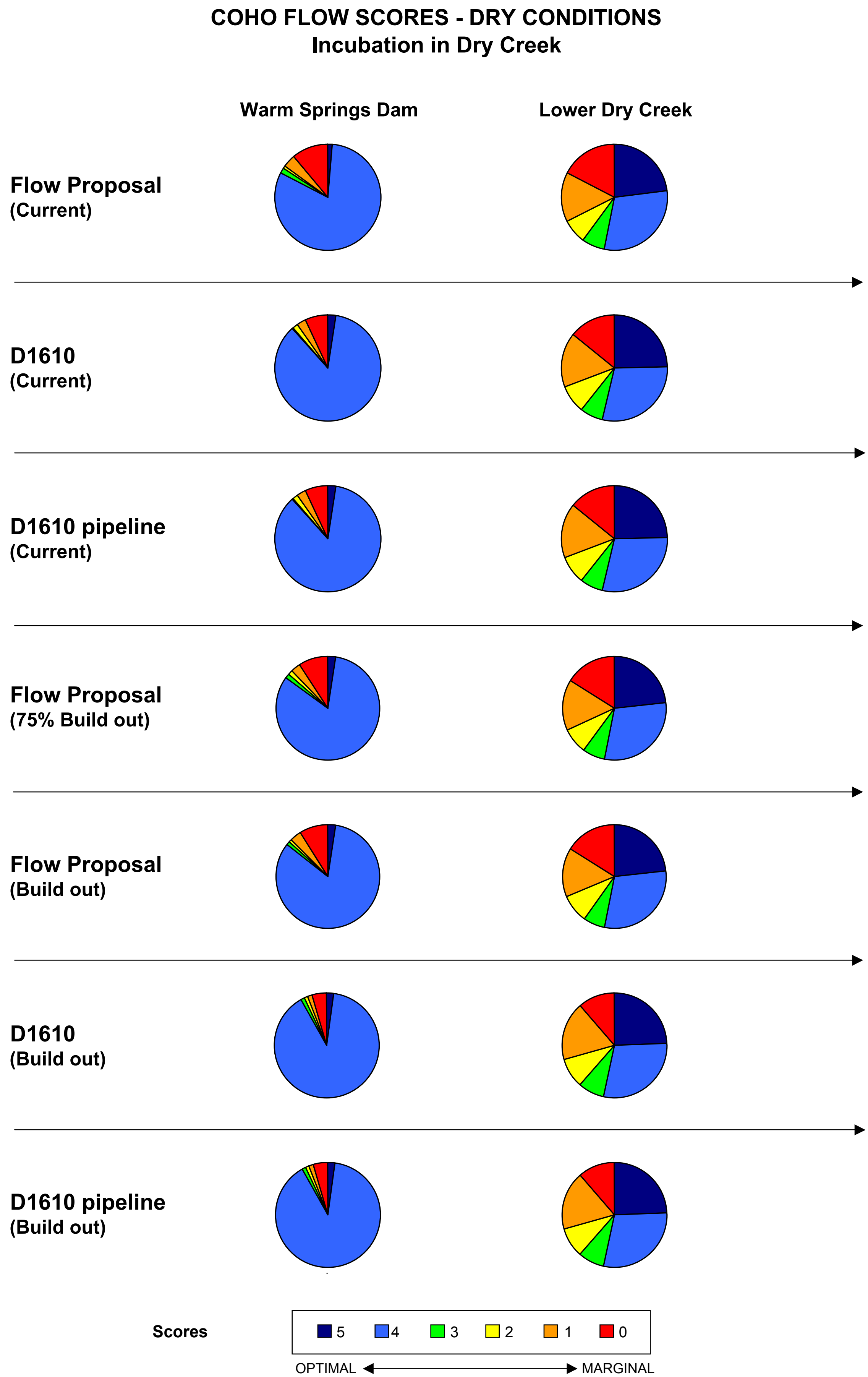

Figure A-8 Coho Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

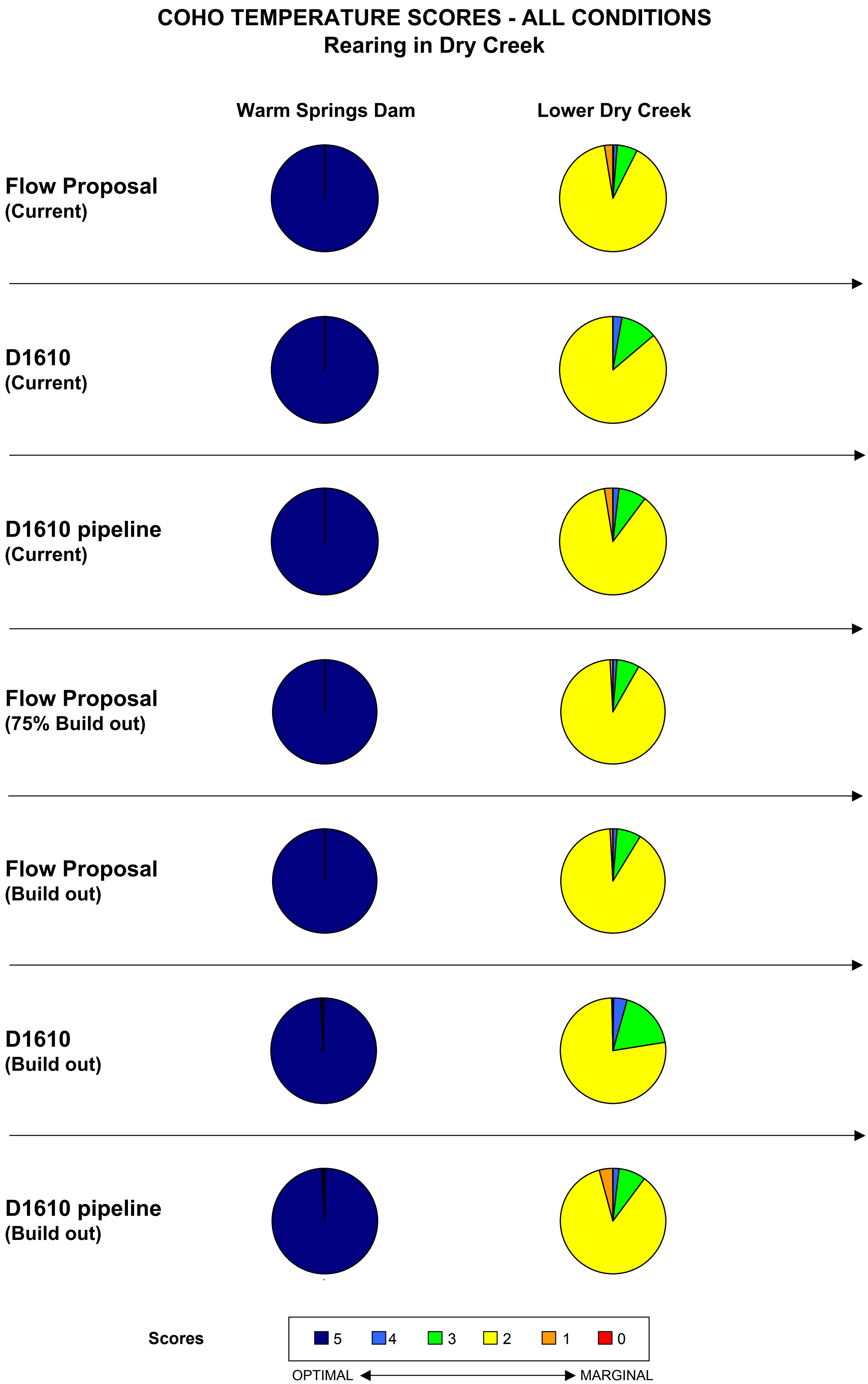

Figure A-9 Coho Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

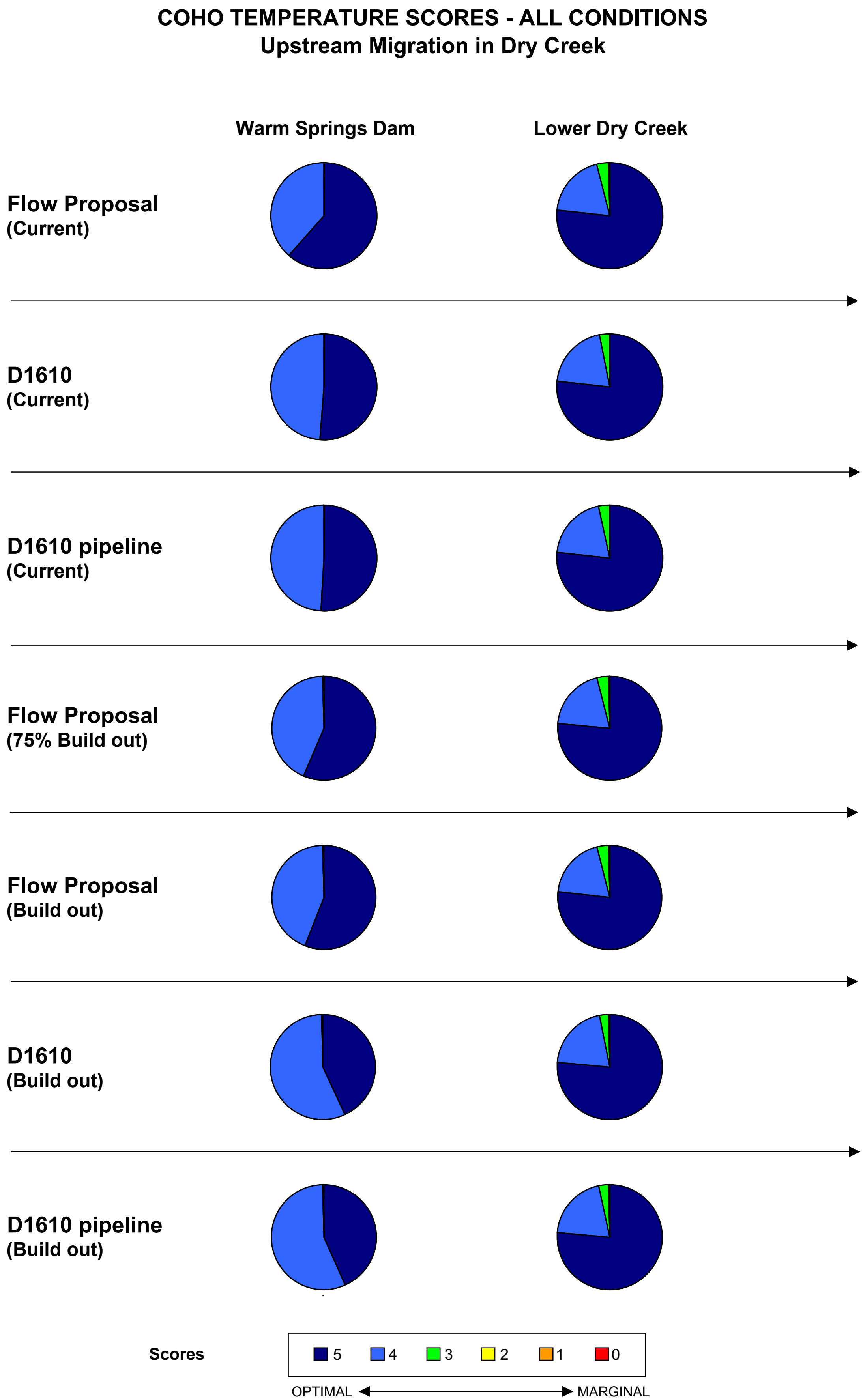

Figure A-10 Coho Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

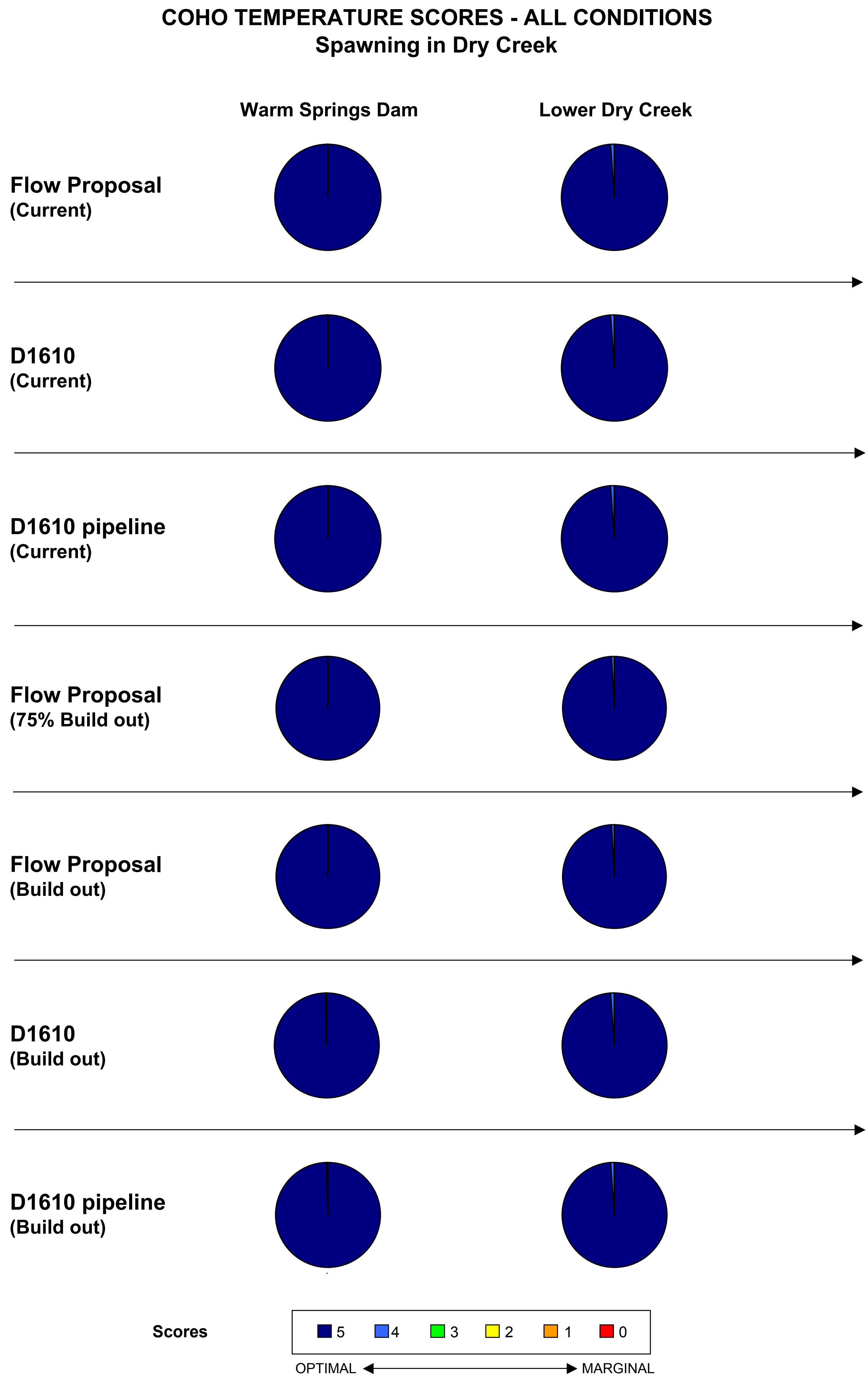

Figure A-11 Coho Spawning Temperature Scores for All Water Supply Conditions in Dry Creek

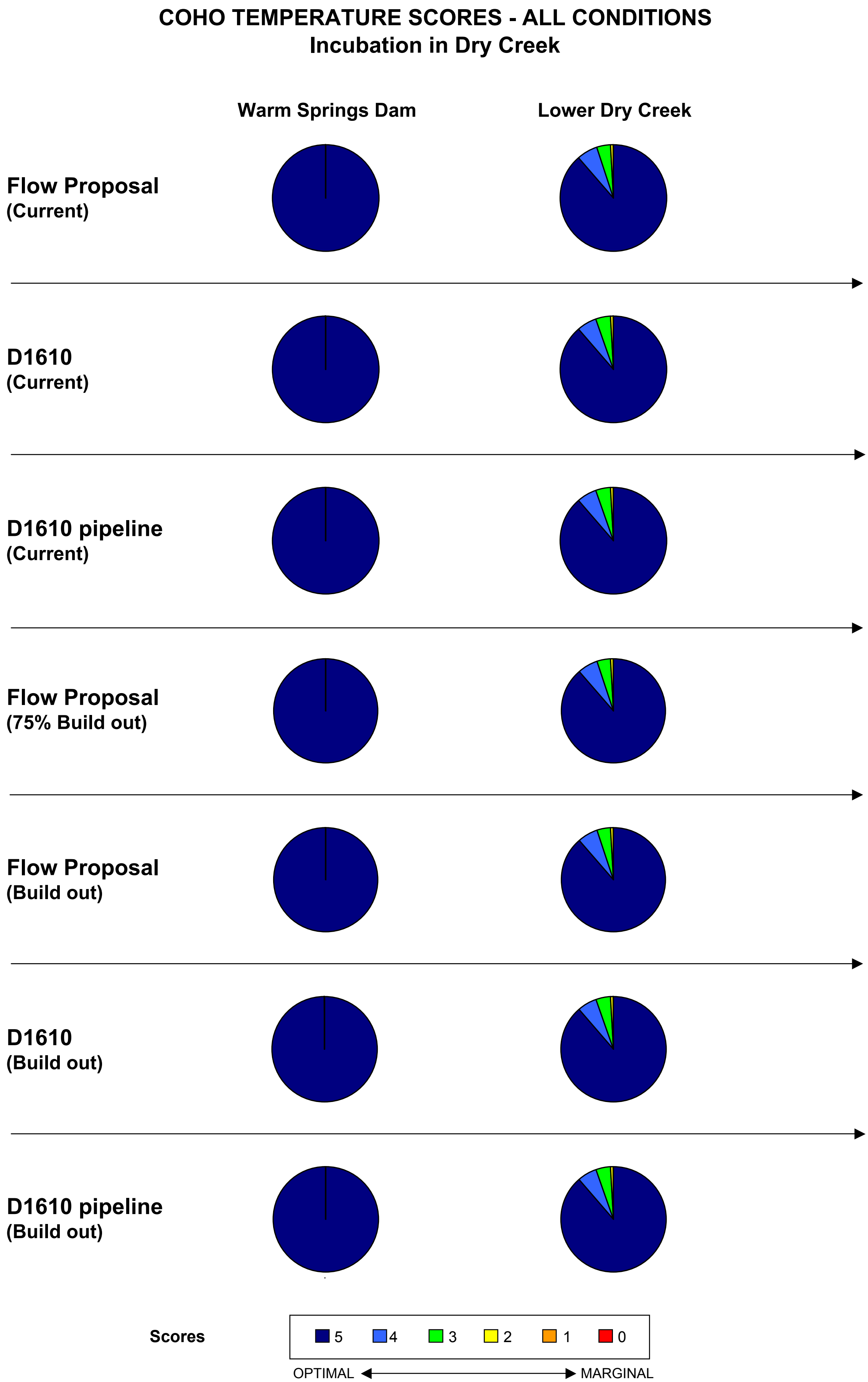

Figure A-12 Coho Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

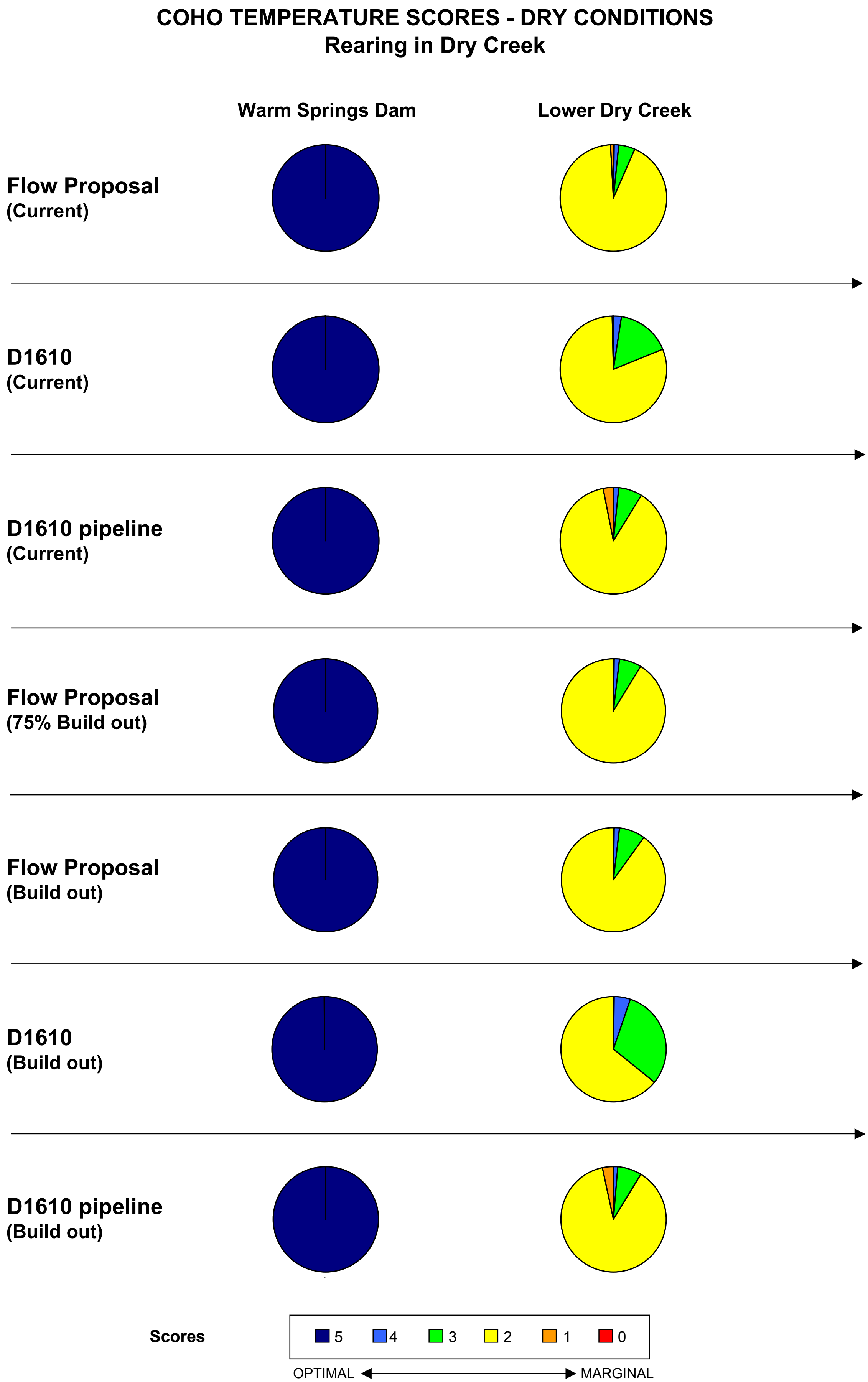

Figure A-13 Coho Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek

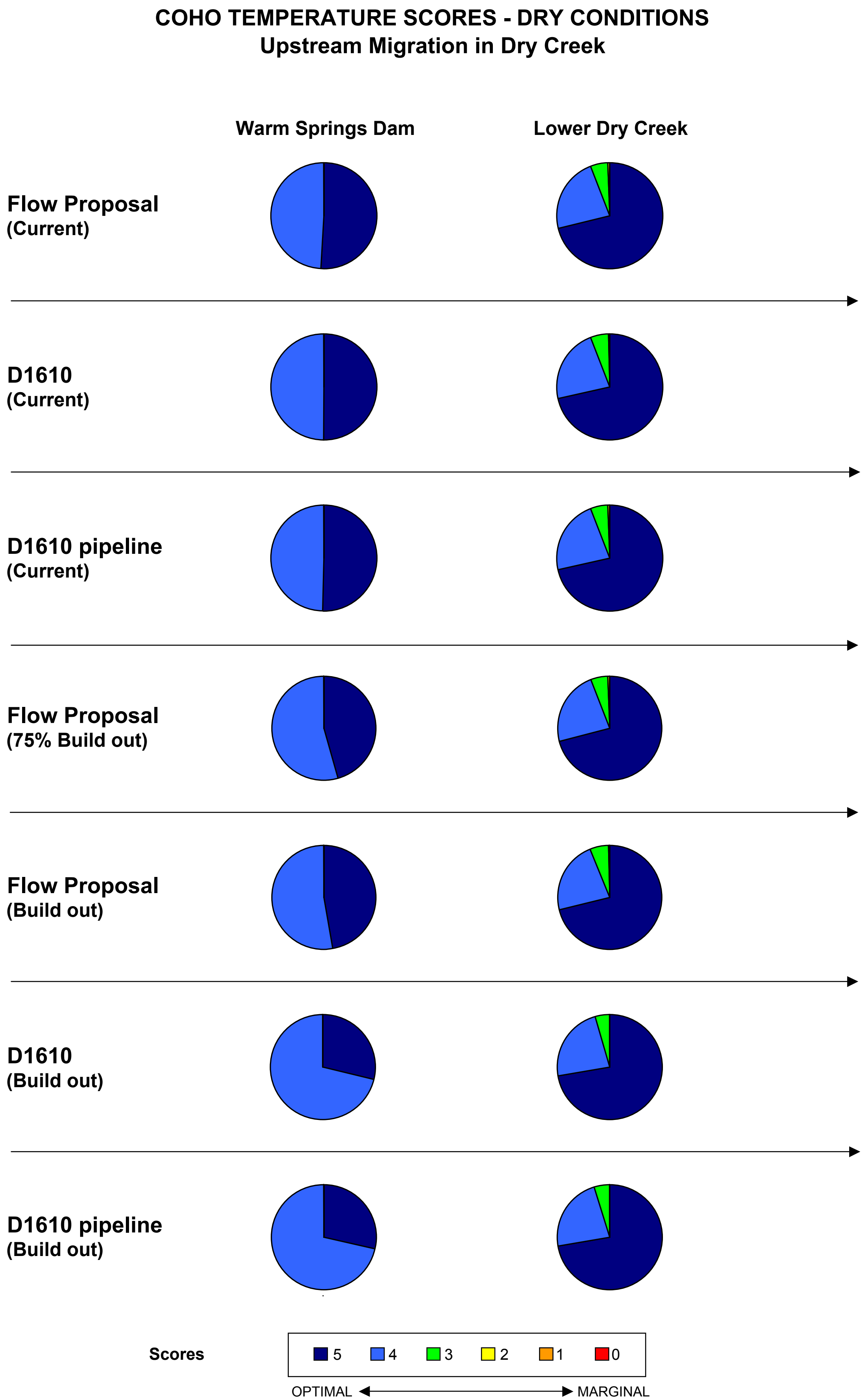

Figure A-14 **Coho Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek**

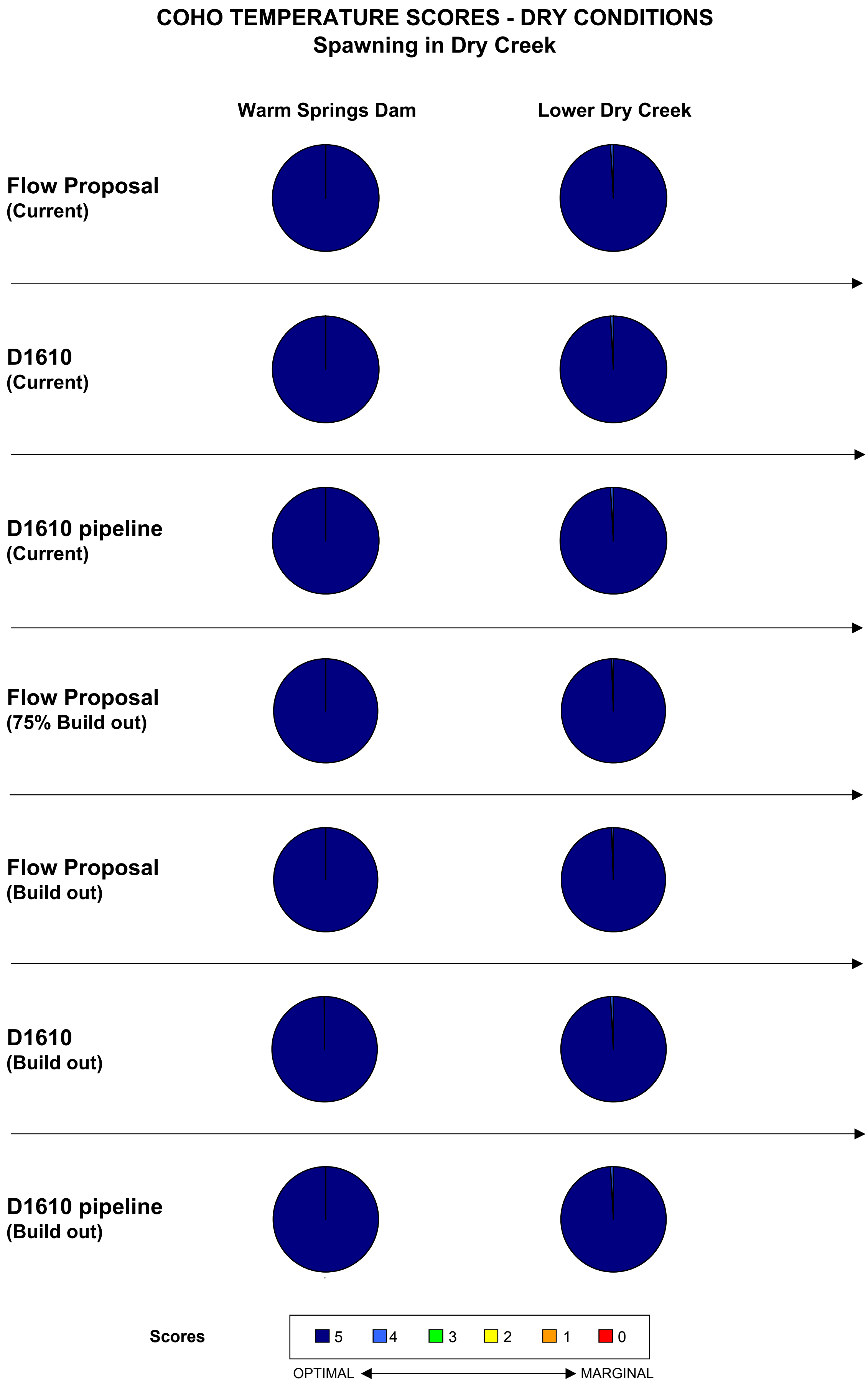

Figure A-15 Coho Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

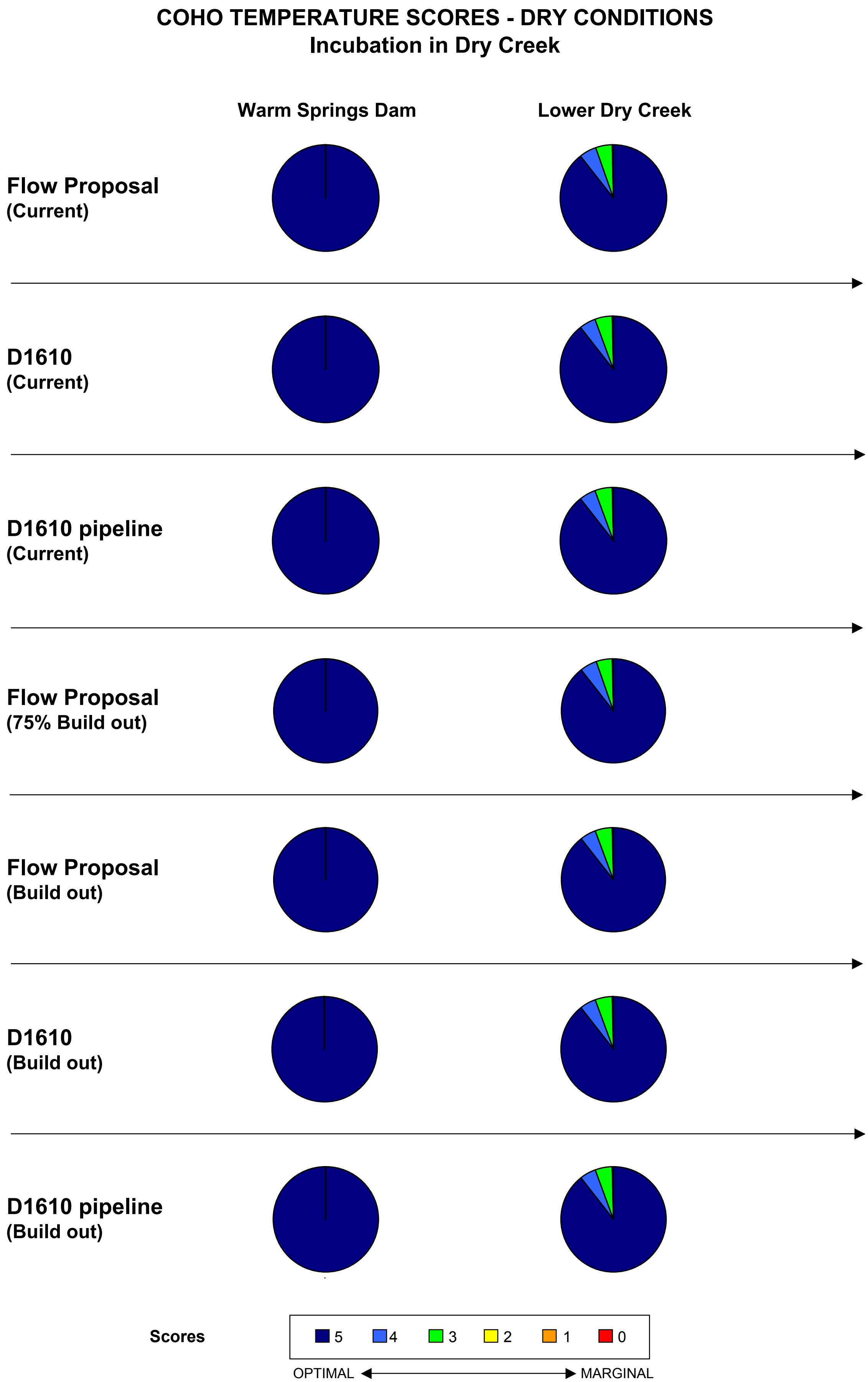

Figure A-16 Coho Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

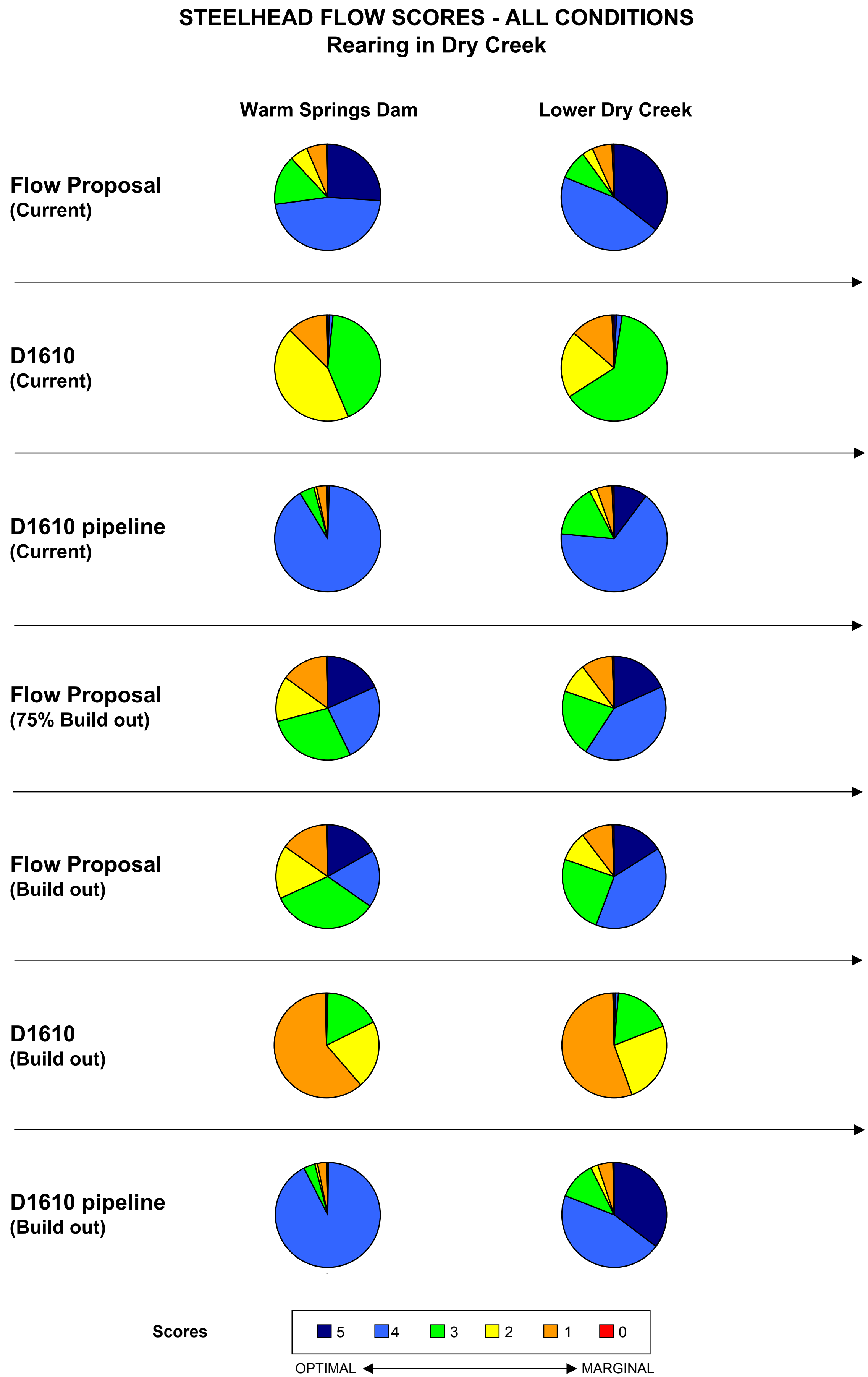

Figure A-17 Steelhead Rearing Flow Scores for All Water Supply Conditions in Dry Creek

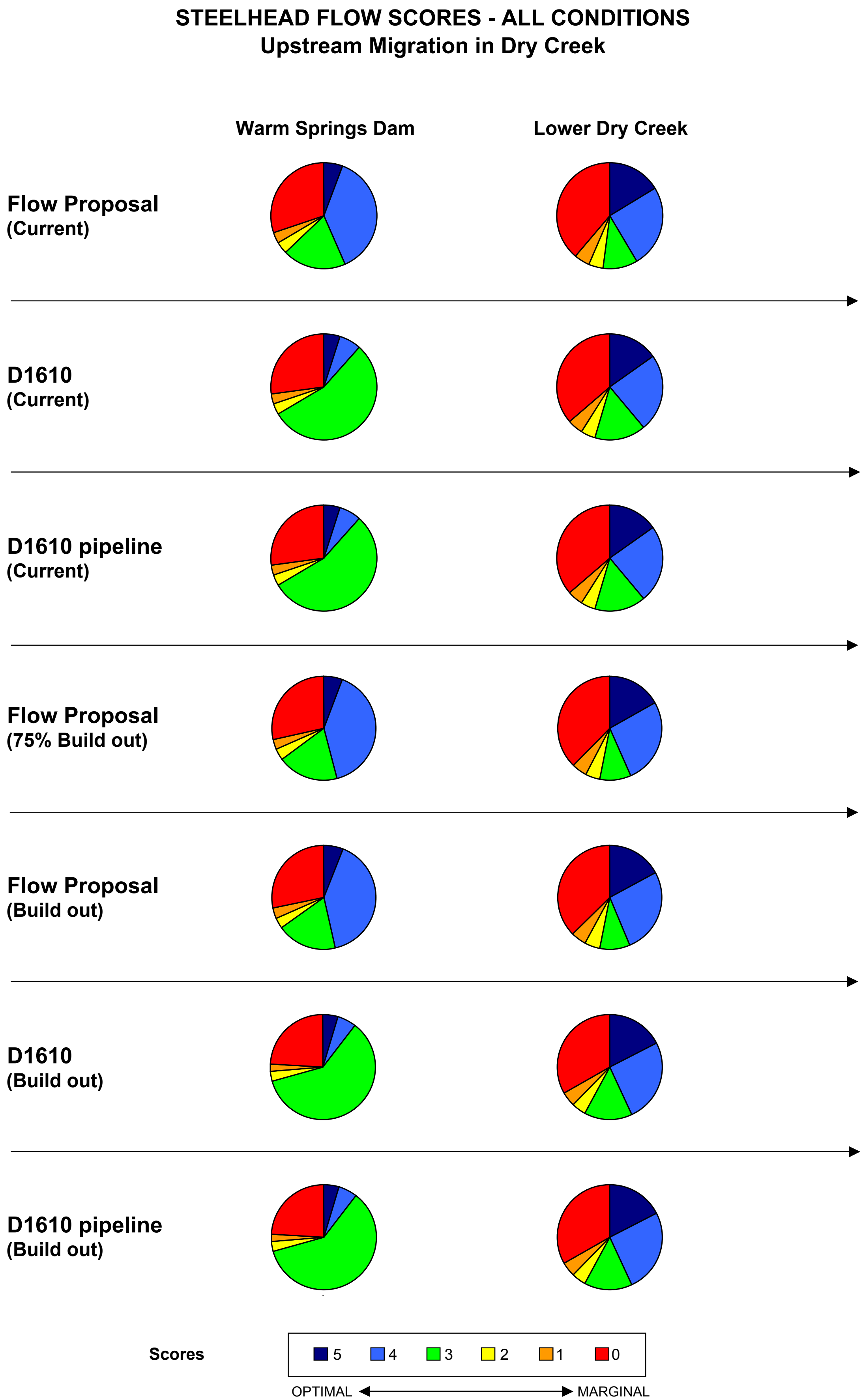

Figure A-18 Steelhead Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

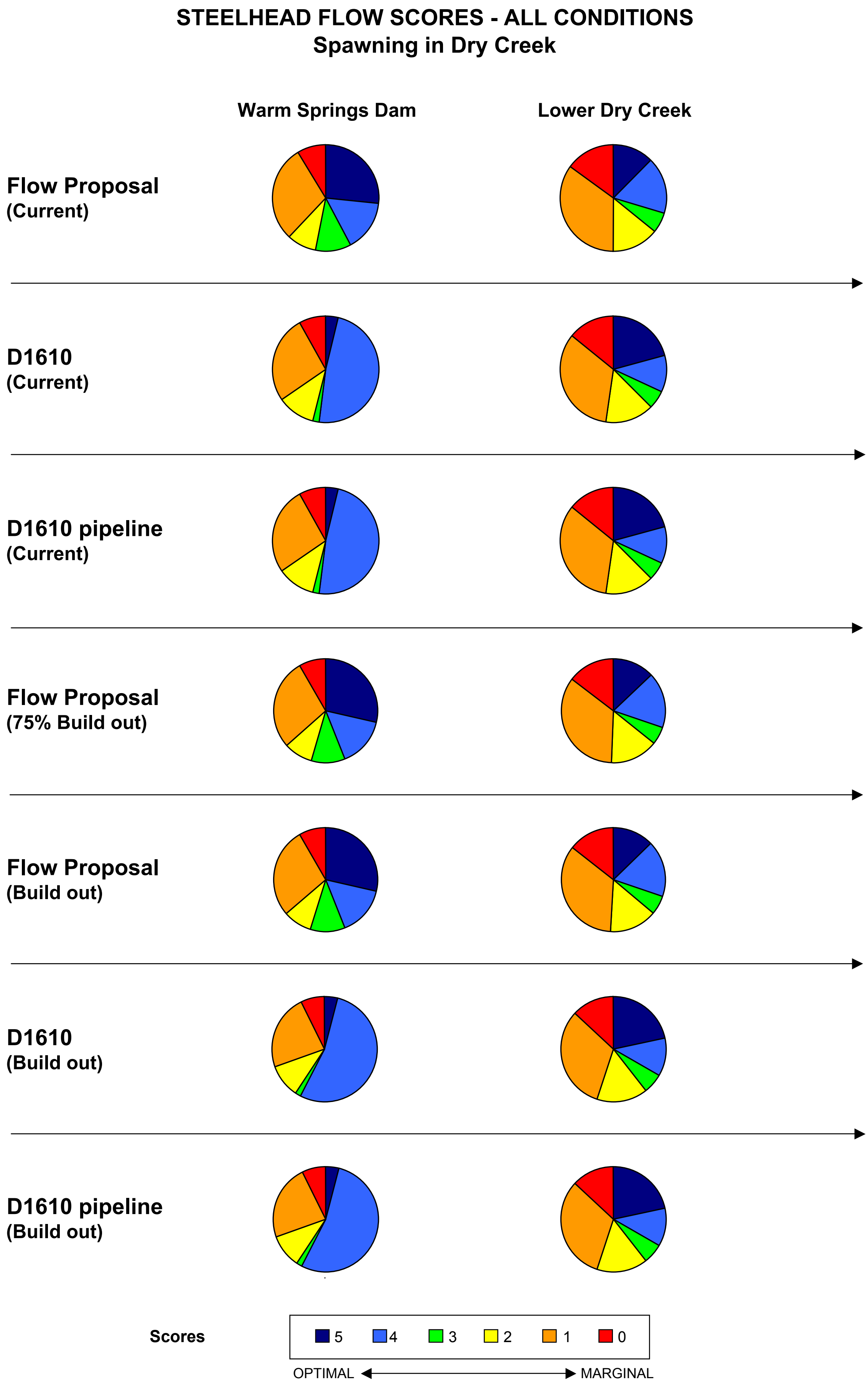

Figure A-19 Steelhead Spawning Flow Scores for All Water Supply Conditions in Dry Creek

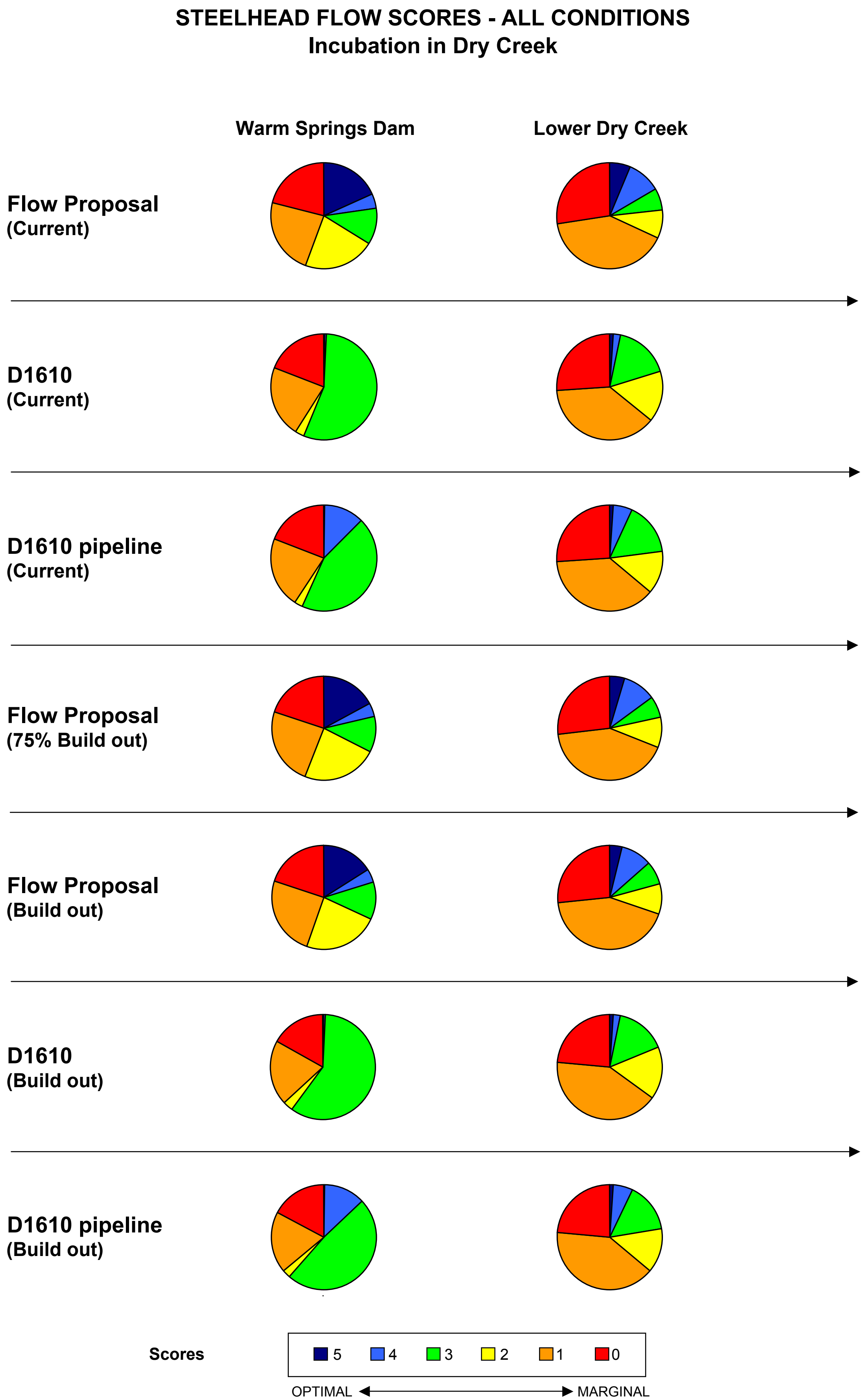

Figure A-20 Steelhead Incubation Flow Scores for All Water Supply Conditions in Dry Creek

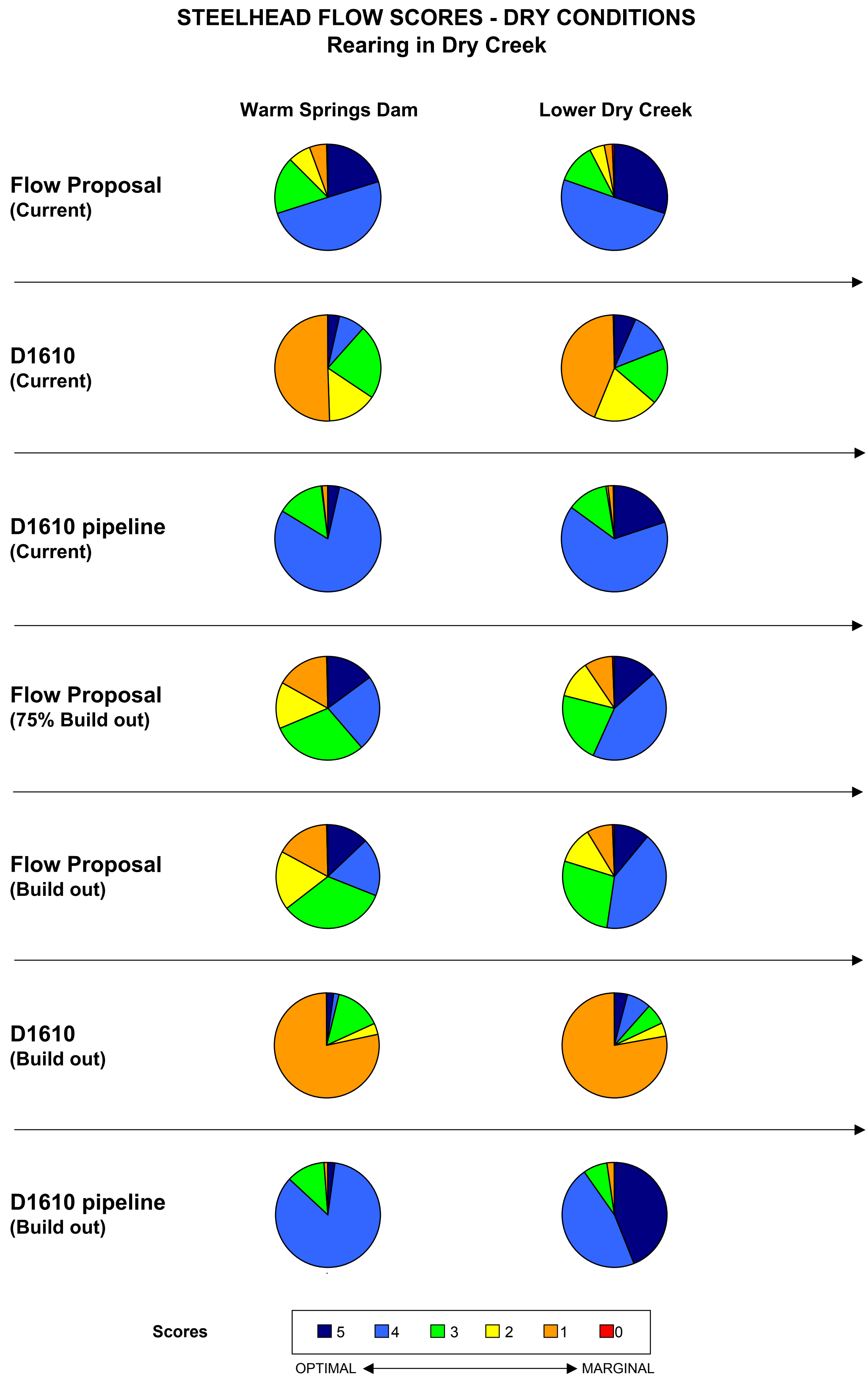

Figure A-21 Steelhead Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

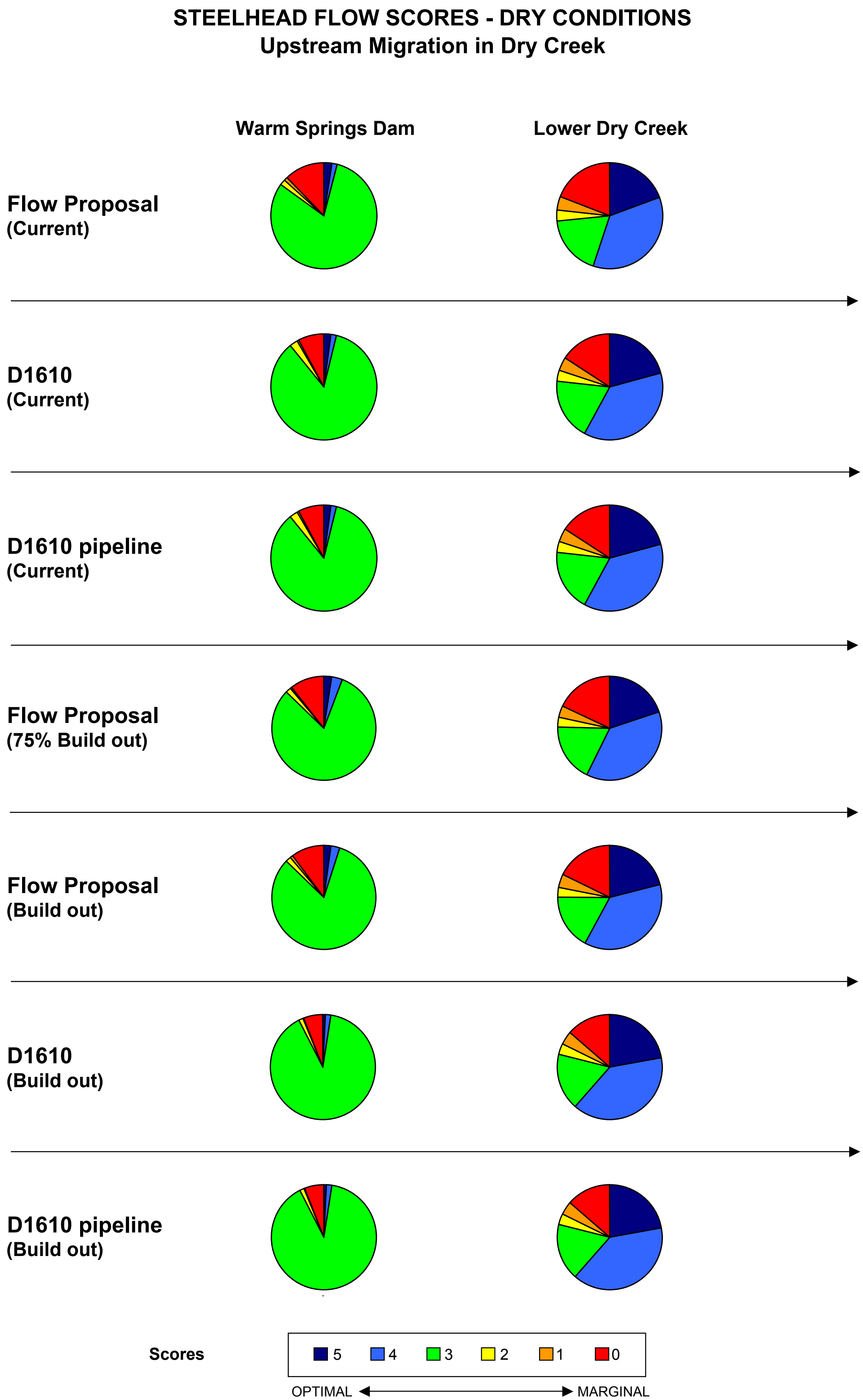

Figure A-22 Steelhead Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

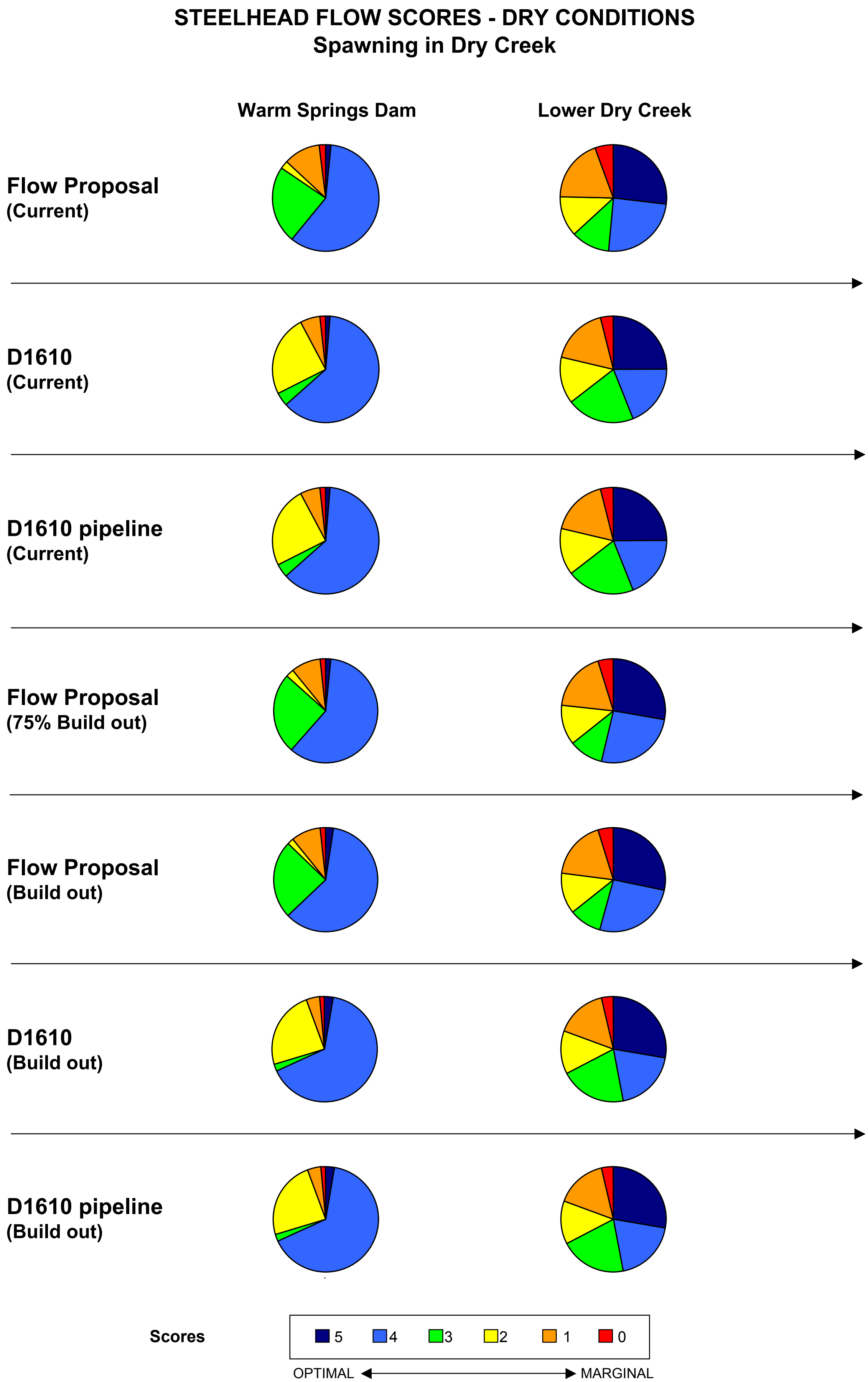

Figure A-23 Steelhead Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

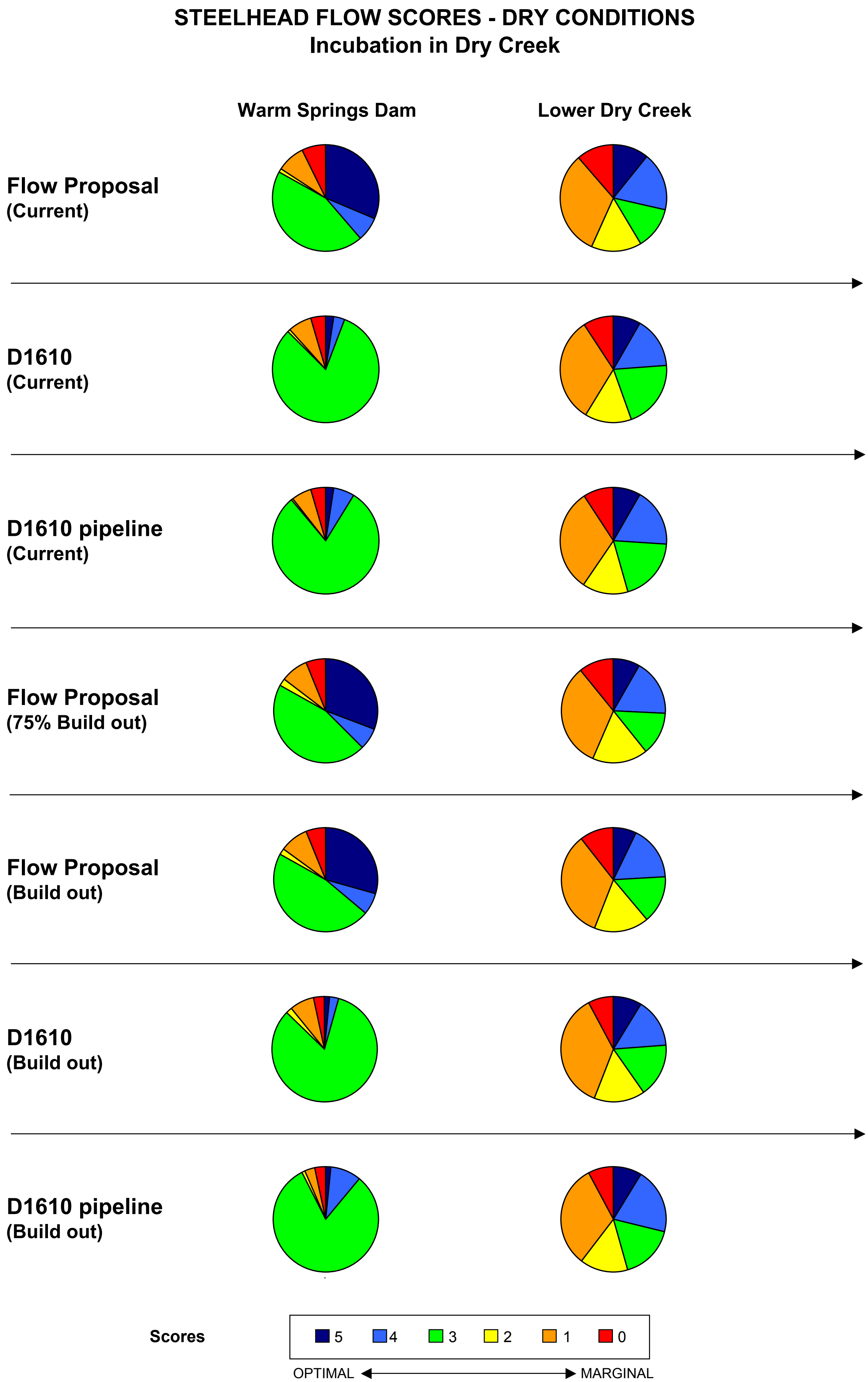

Figure A-24 Steelhead Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

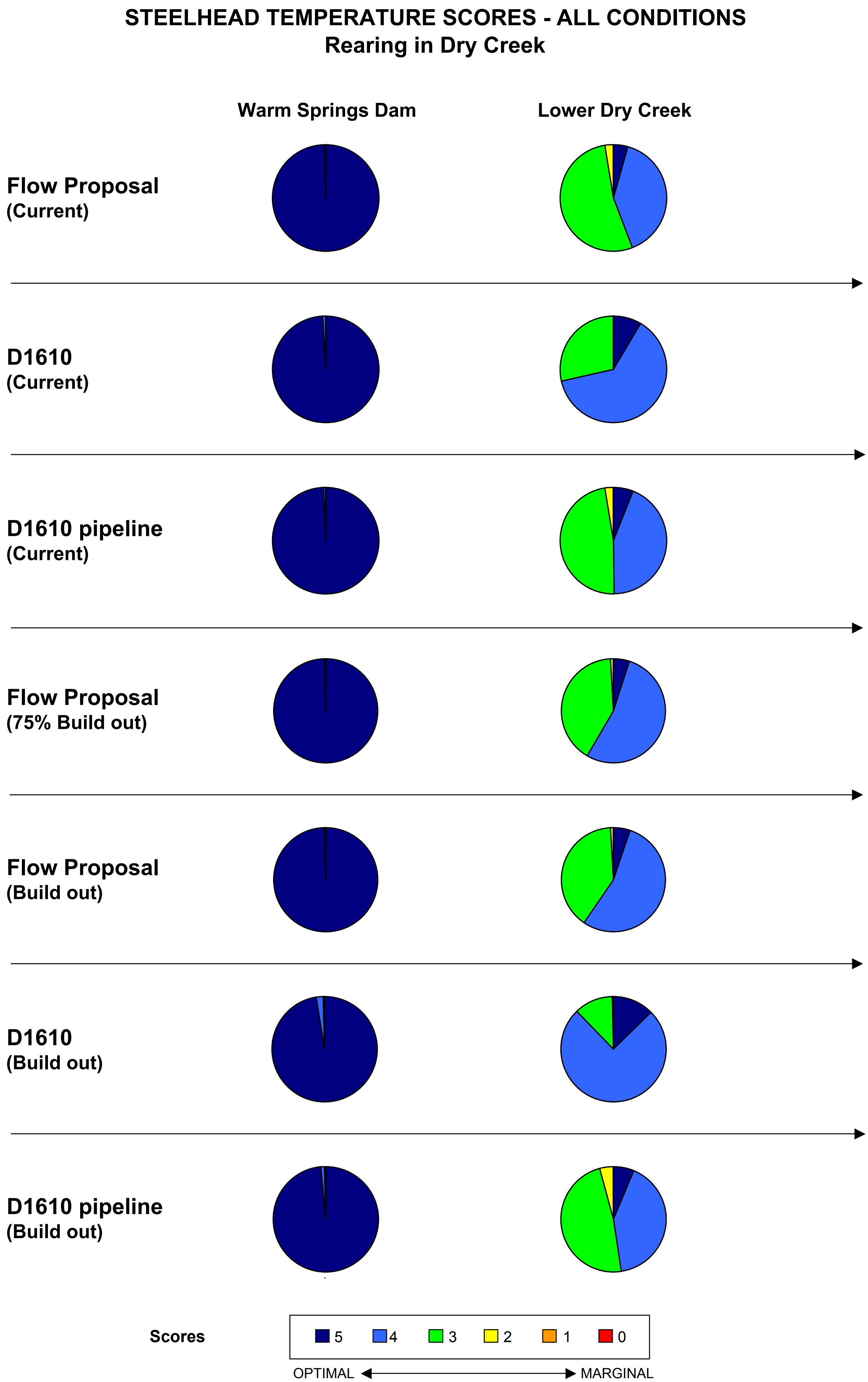

Figure A-25 Steelhead Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

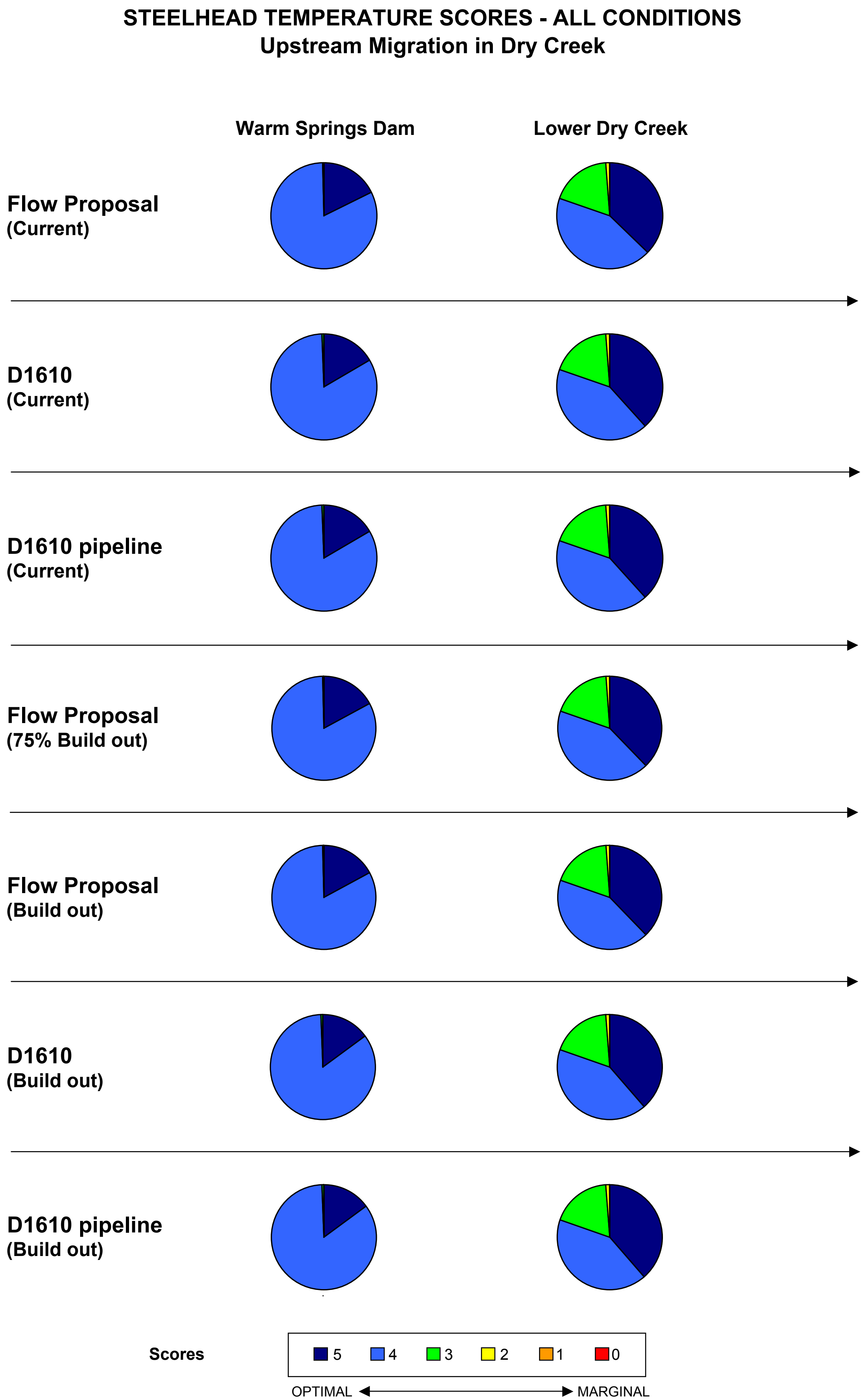

Figure A-26 Steelhead Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

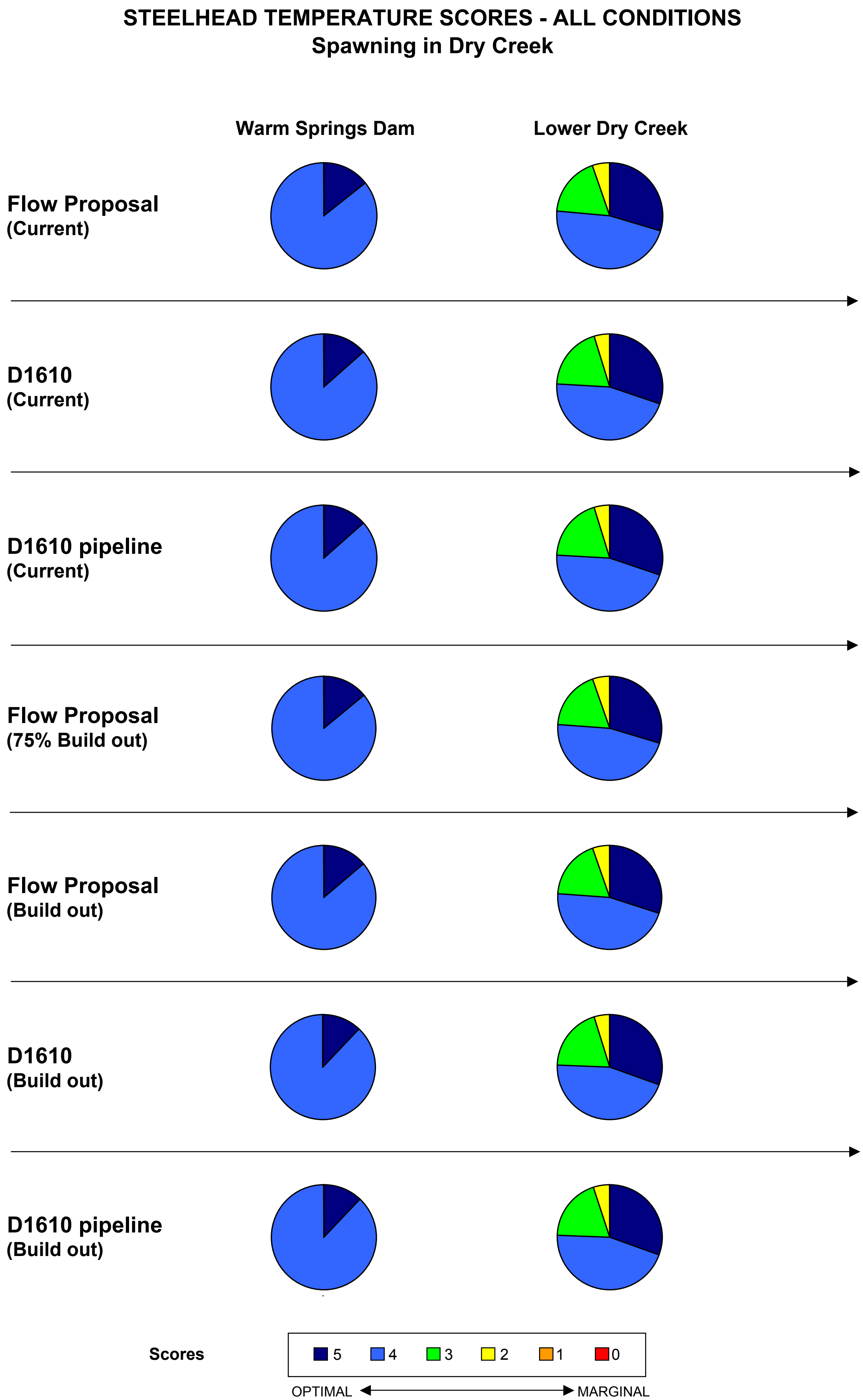

Figure A-27 Steelhead Spawning Temperature Scores for All Water Supply Conditions in Dry Creek

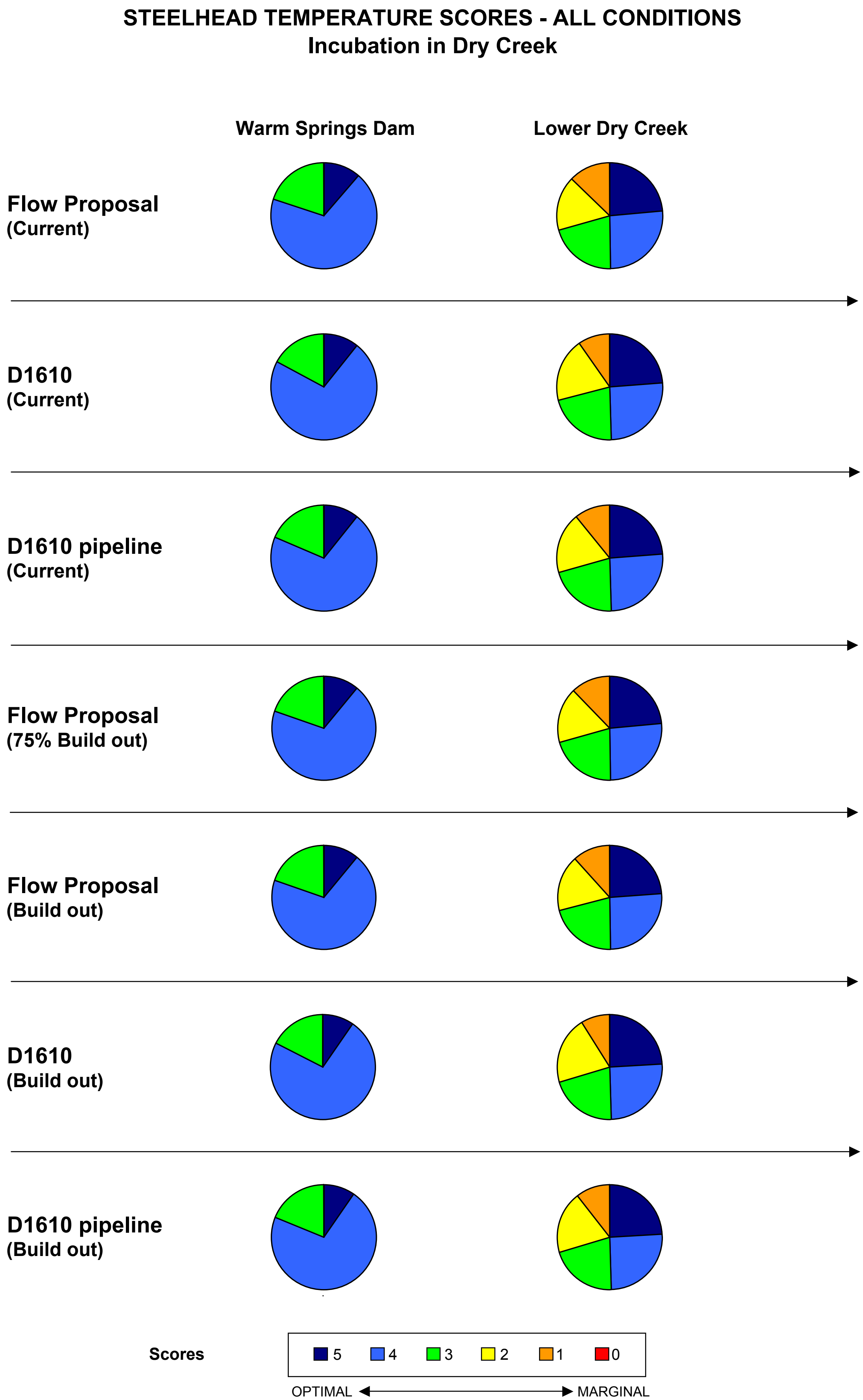

Figure A-28 Steelhead Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

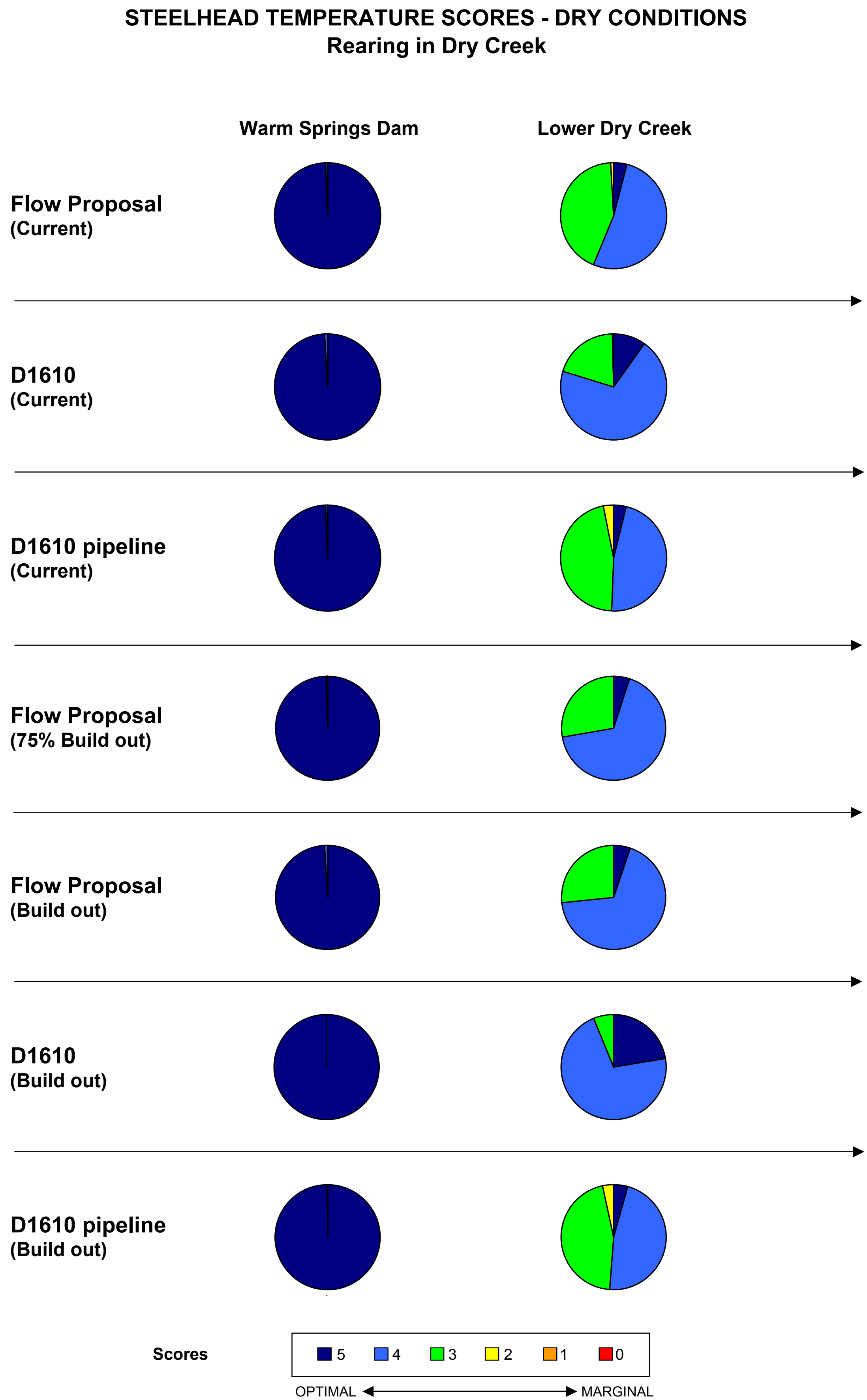

Figure A-29 **Steelhead Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek**

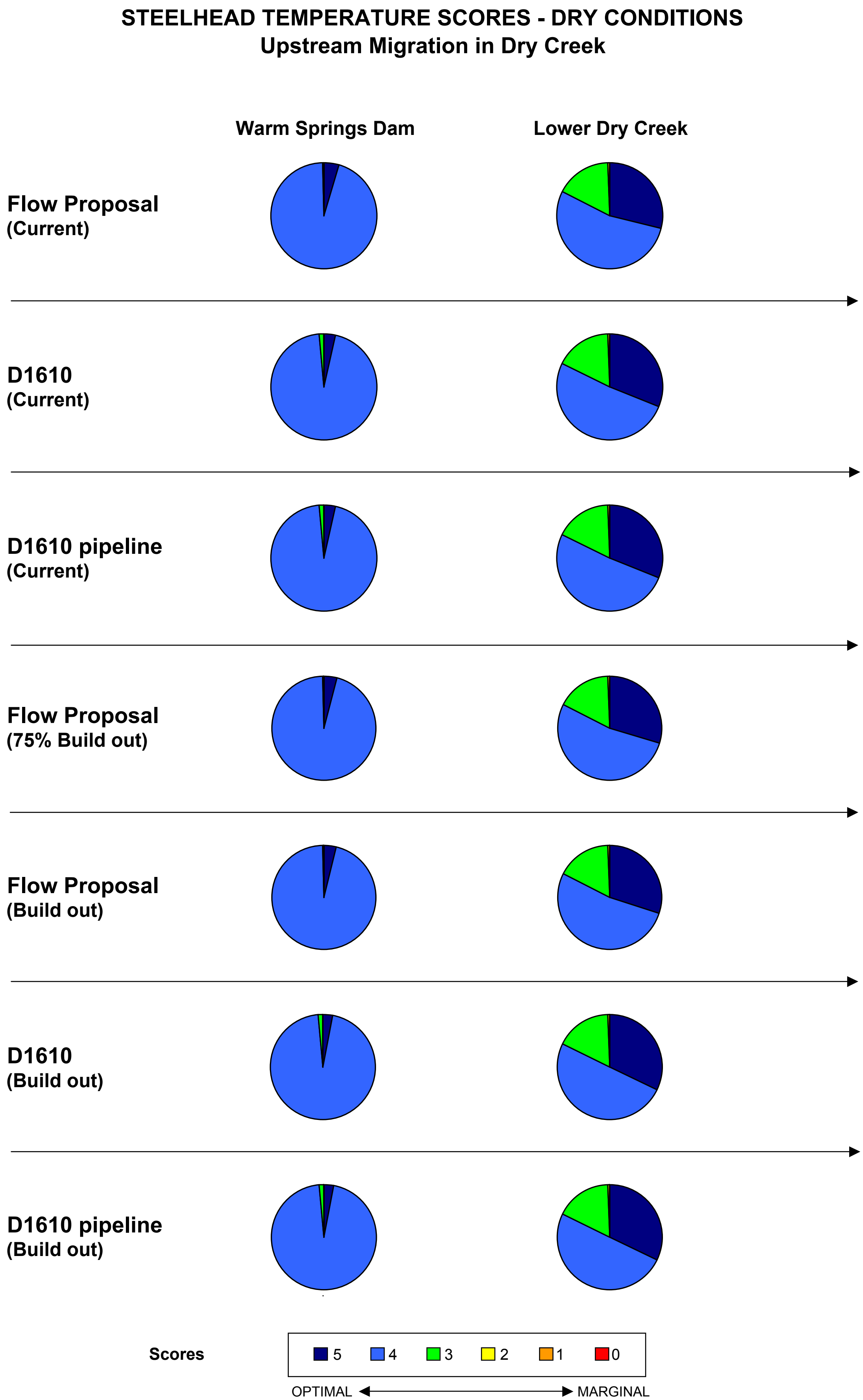

Figure A-30 Steelhead Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek

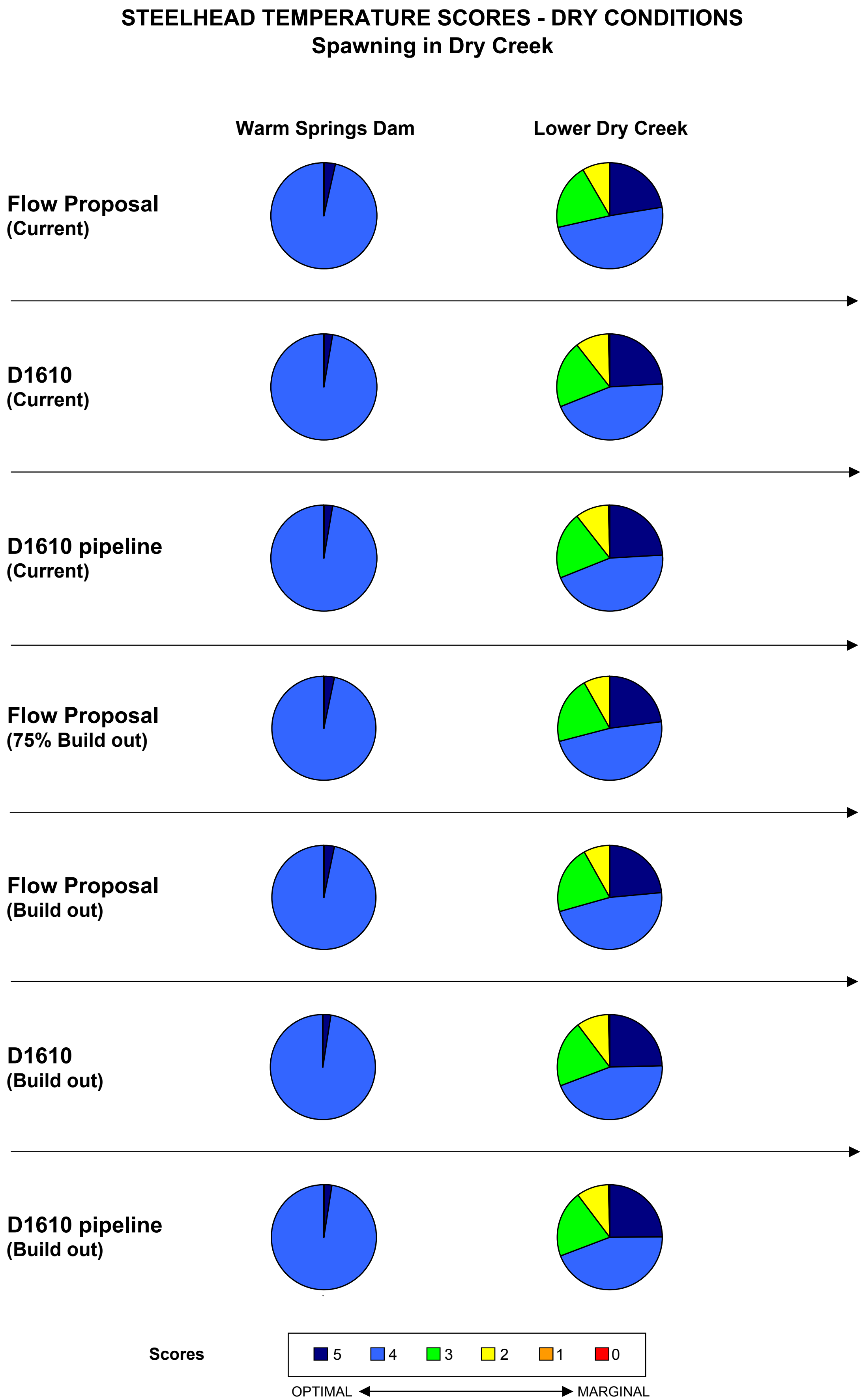

Figure A-31 Steelhead Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

STEELHEAD TEMPERATURE SCORES - DRY CONDITIONS
Incubation in Dry Creek

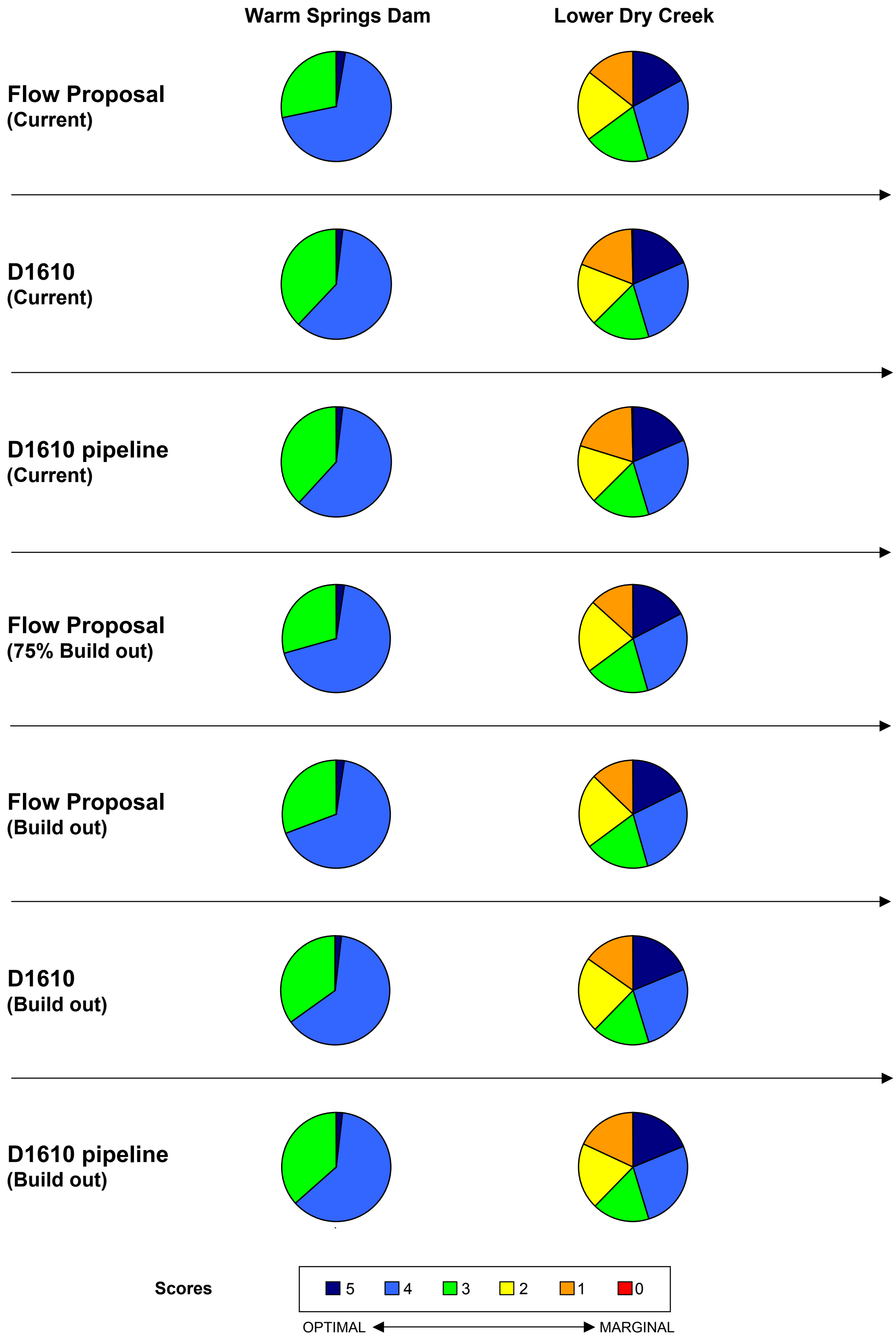

Figure A-32 Steelhead Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

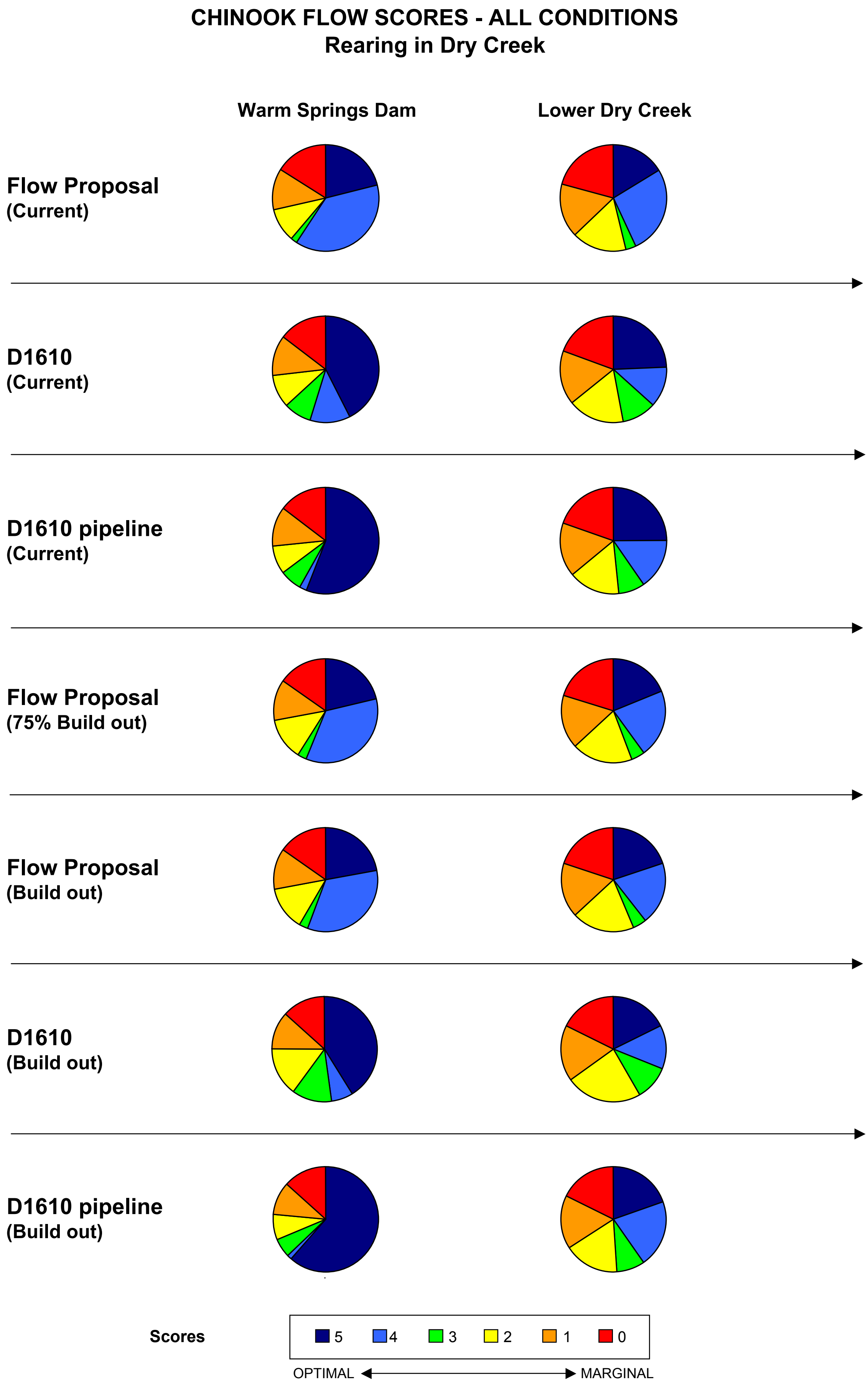

Figure A-33 Chinook Rearing Flow Scores for All Water Supply Conditions in Dry Creek

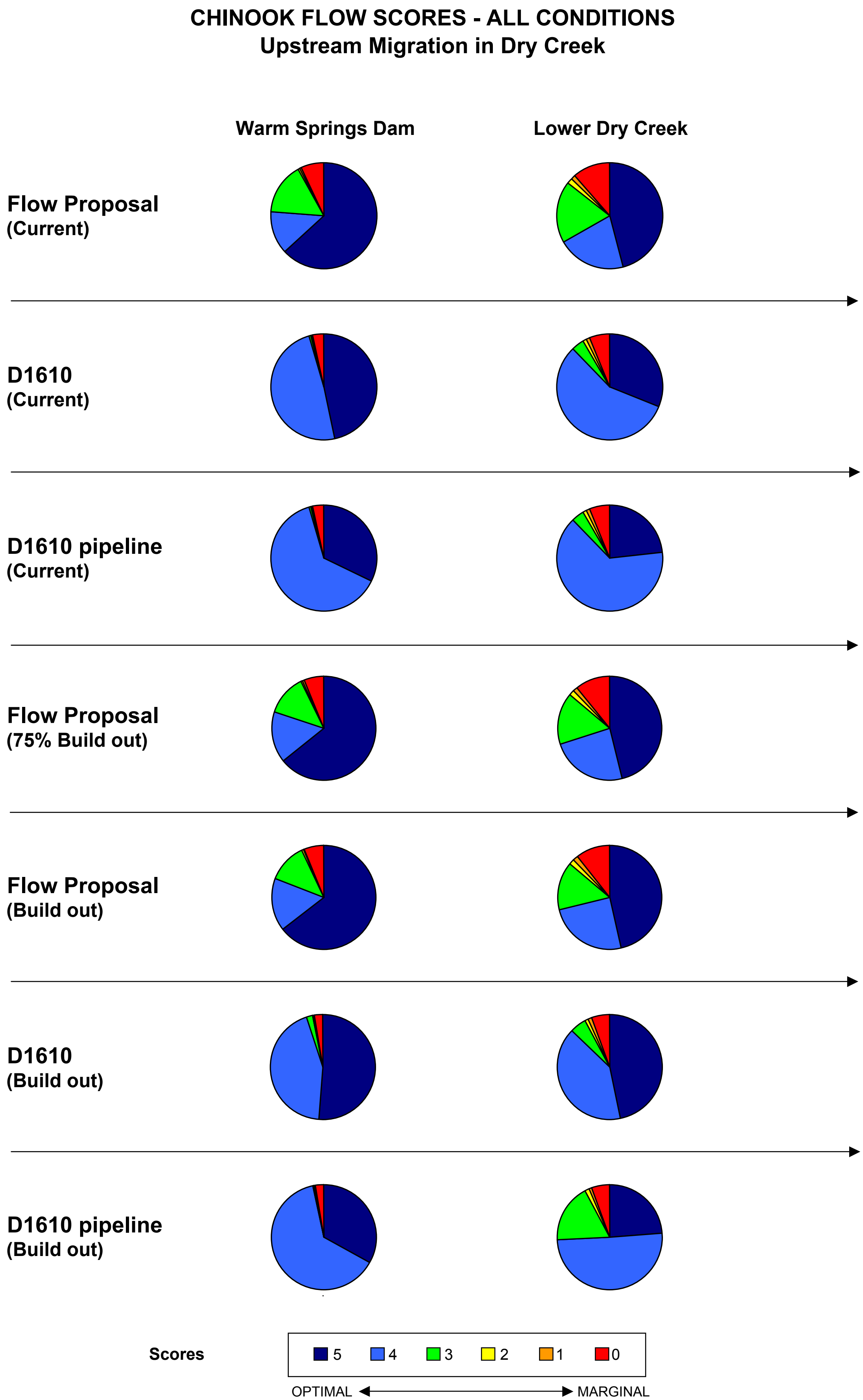

Figure A-34 Chinook Upstream Migration Flow Scores for All Water Supply Conditions in Dry Creek

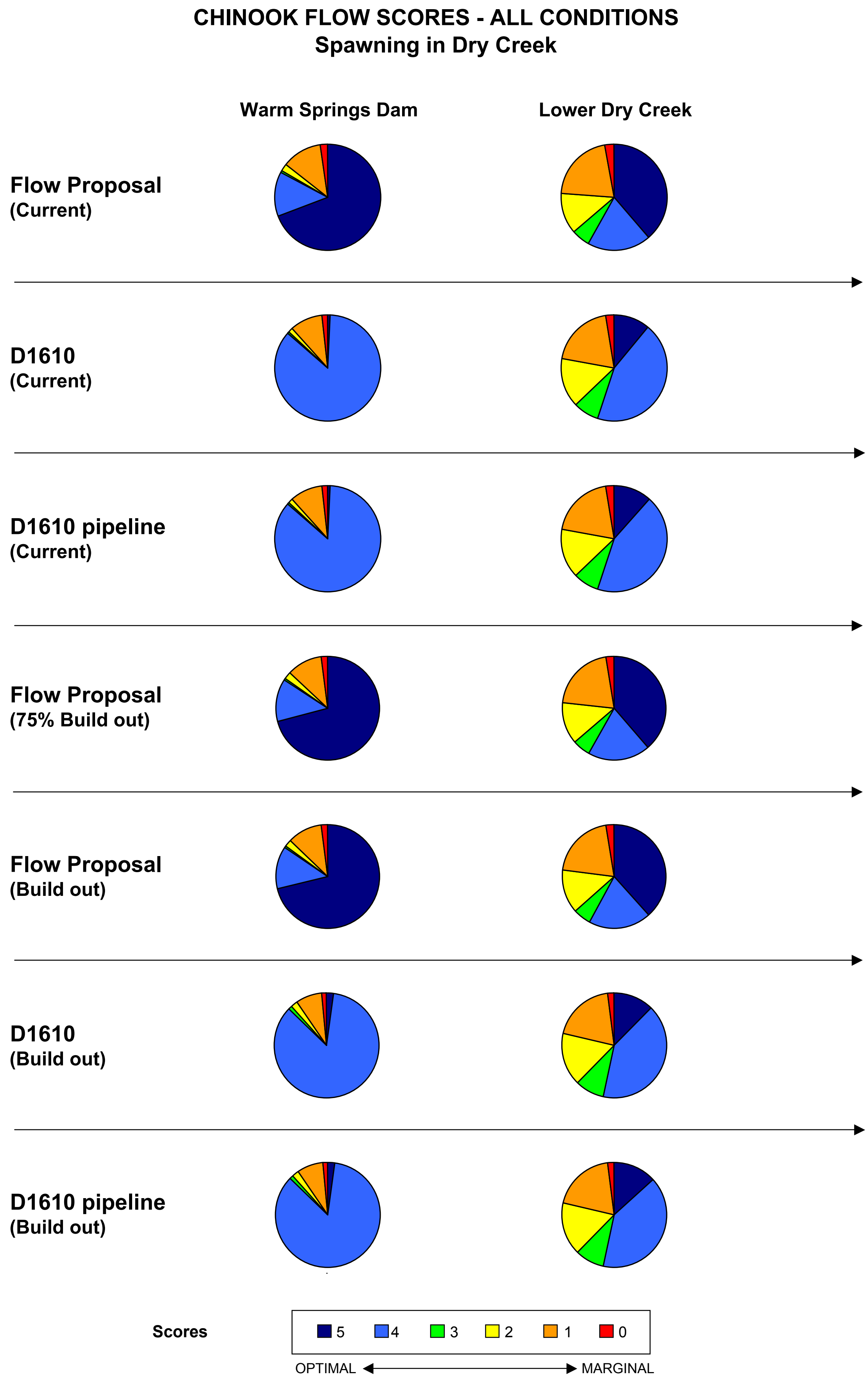

Figure A-35 Chinook Spawning Flow Scores for All Water Supply Conditions in Dry Creek

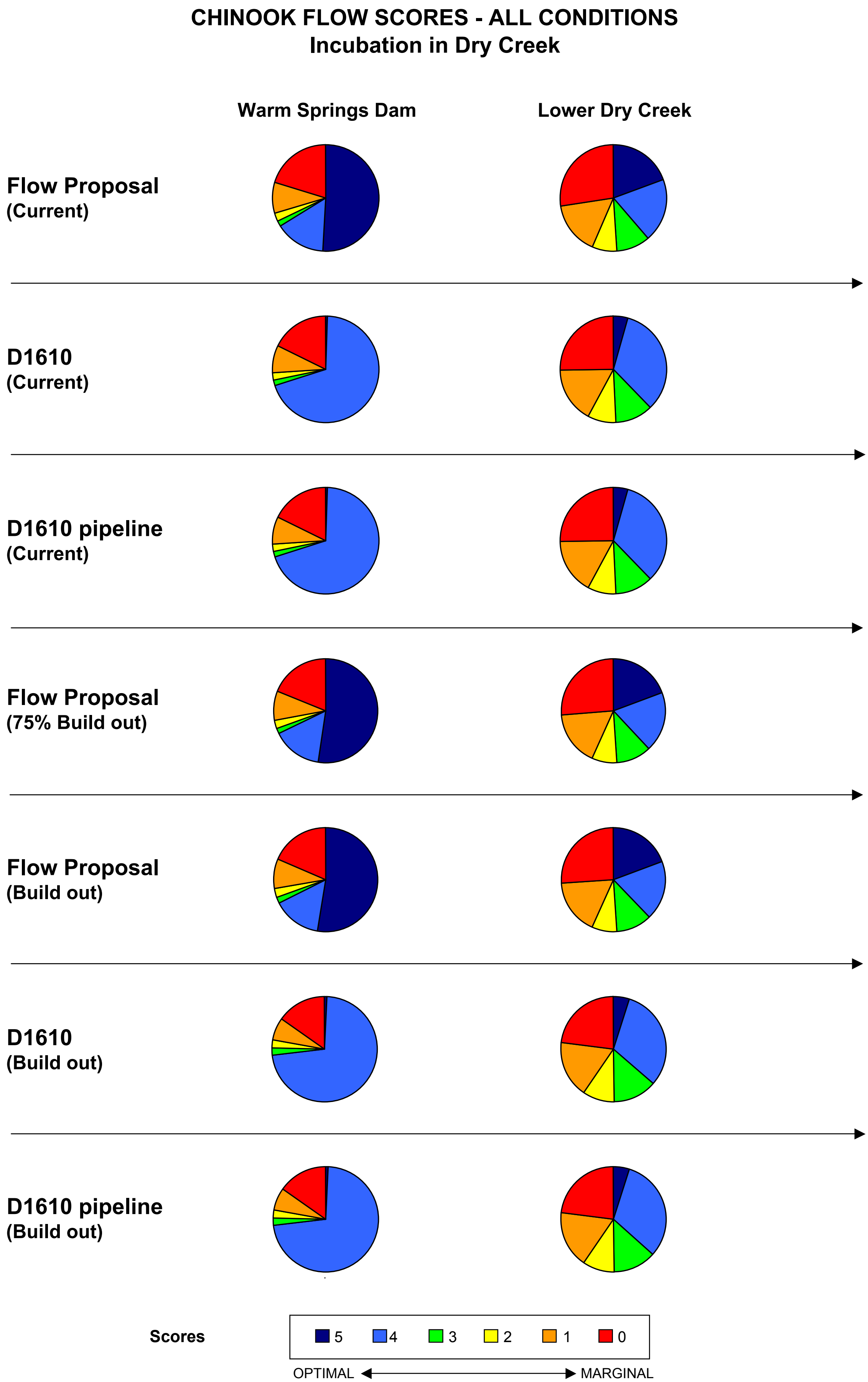

Figure A-36 Chinook Incubation Flow Scores for All Water Supply Conditions in Dry Creek

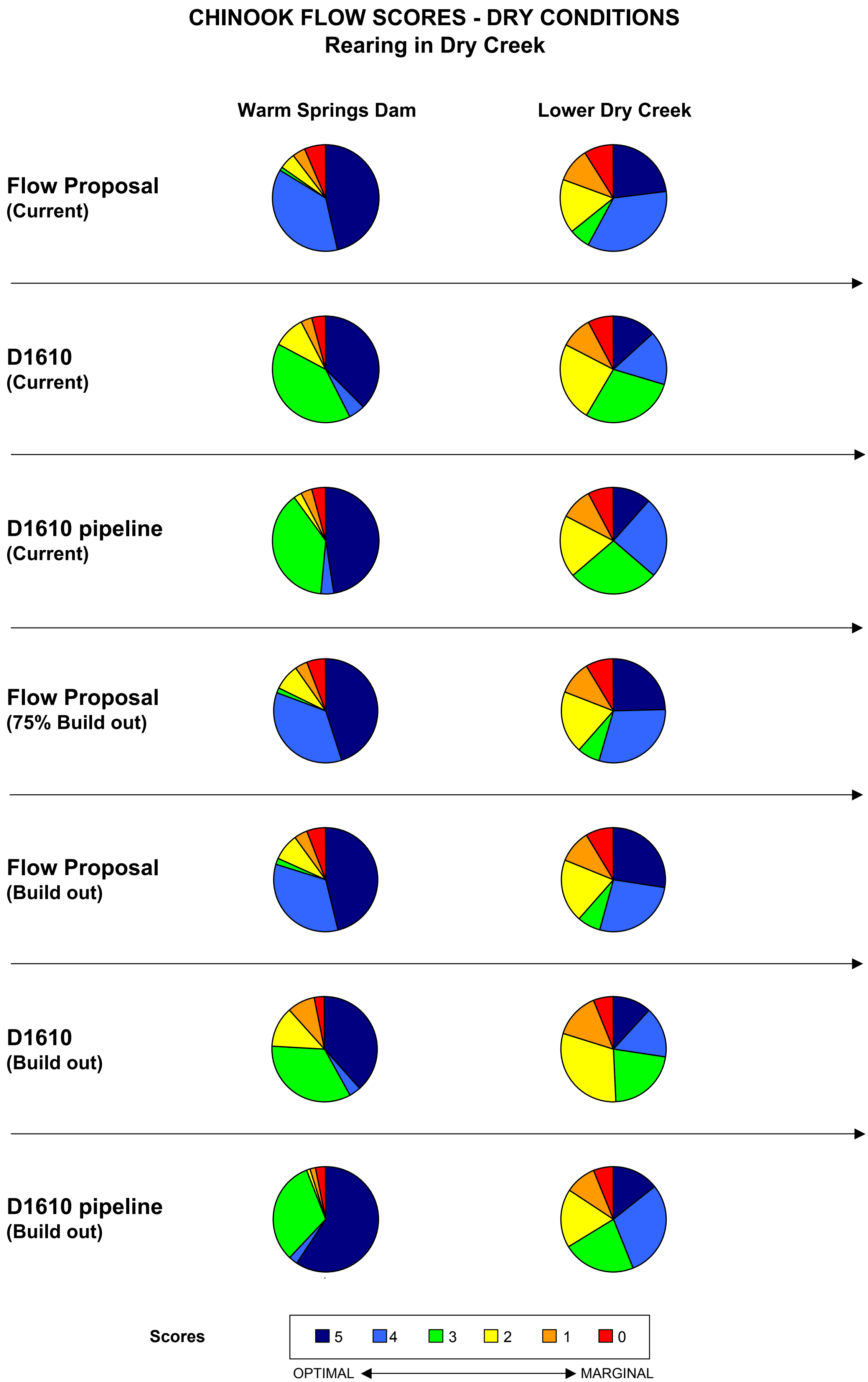

Figure A-37 Chinook Rearing Flow Scores for Dry Water Supply Conditions in Dry Creek

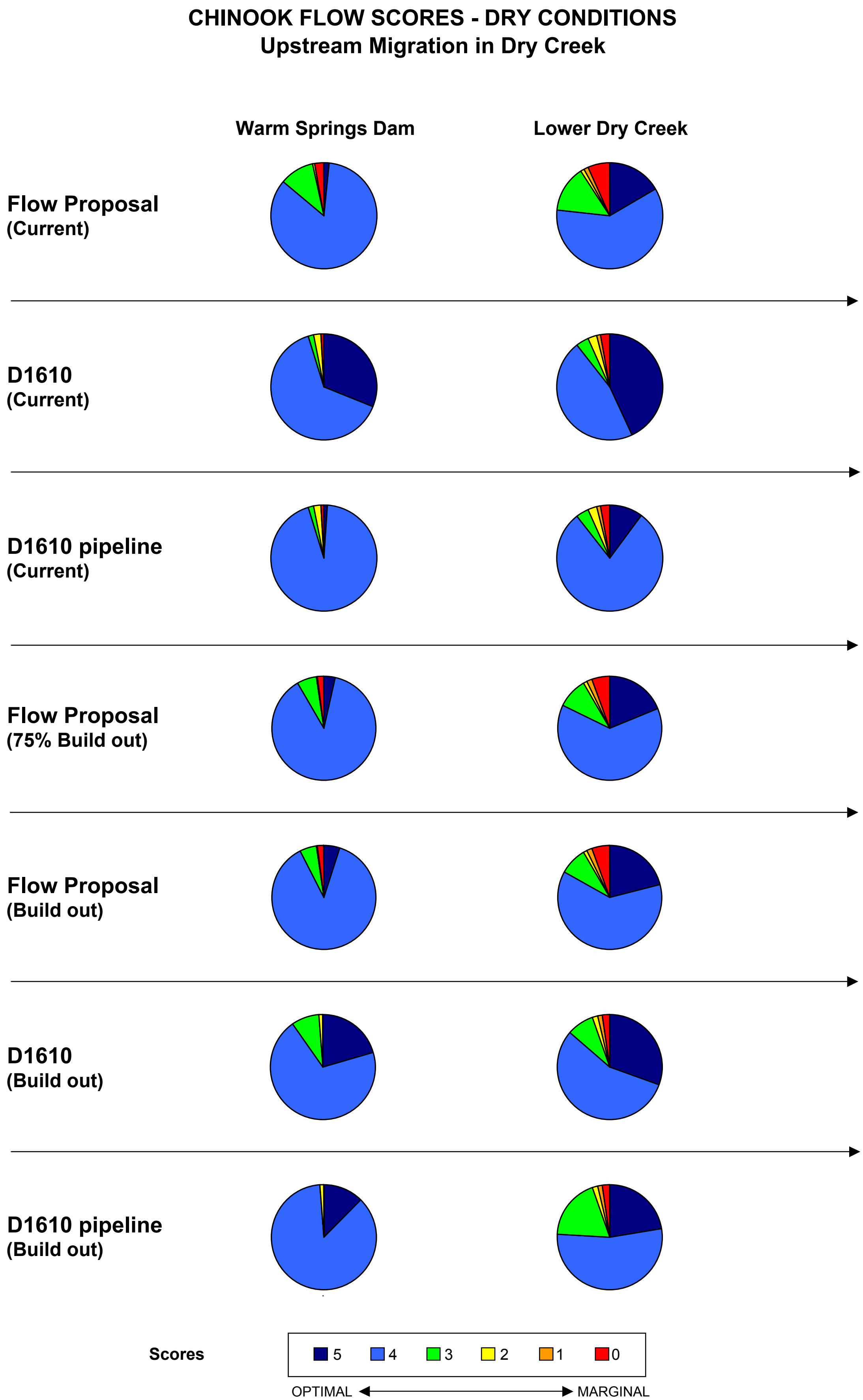

Figure A-38 Chinook Upstream Migration Flow Scores for Dry Water Supply Conditions in Dry Creek

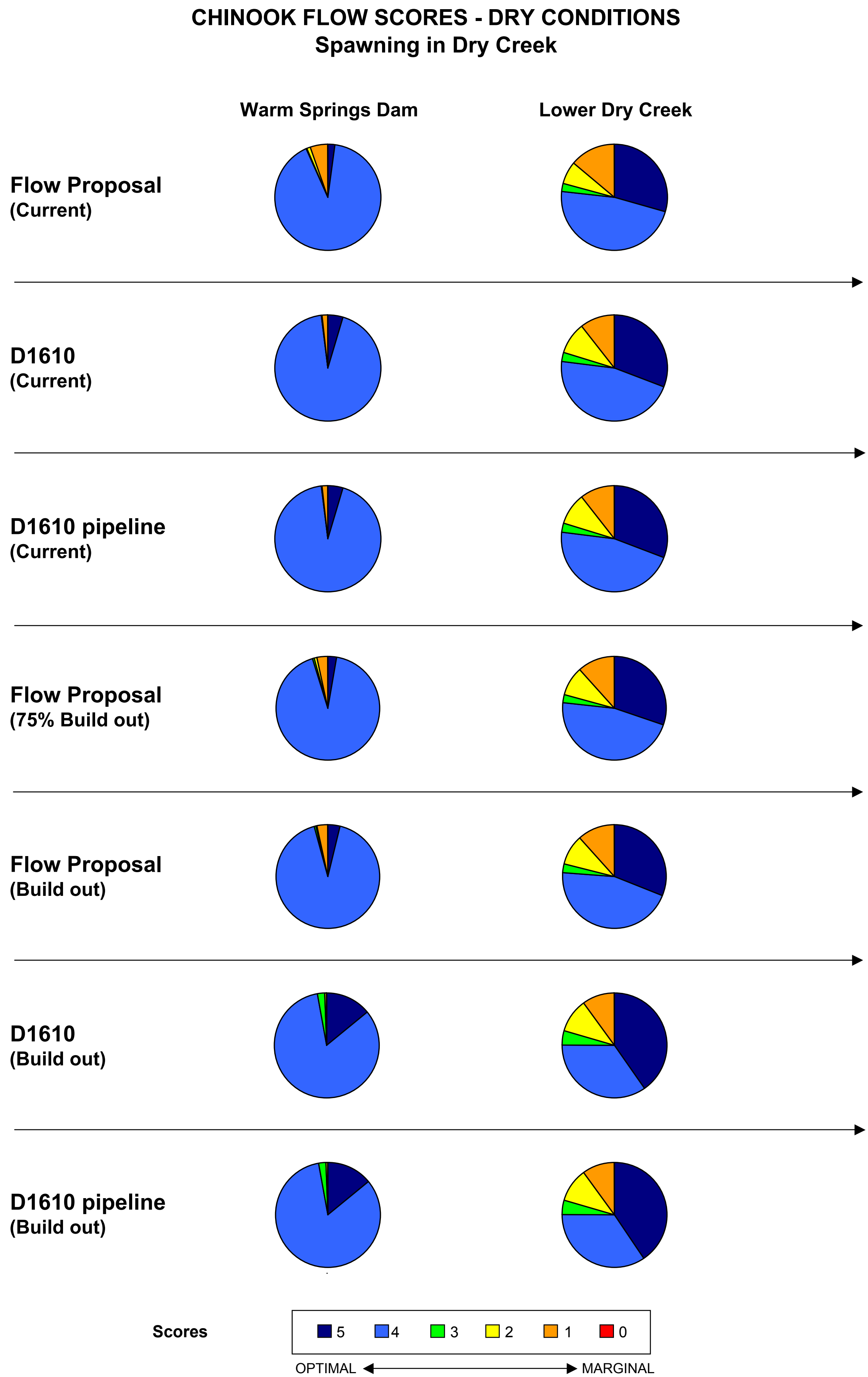

Figure A-39 Chinook Spawning Flow Scores for Dry Water Supply Conditions in Dry Creek

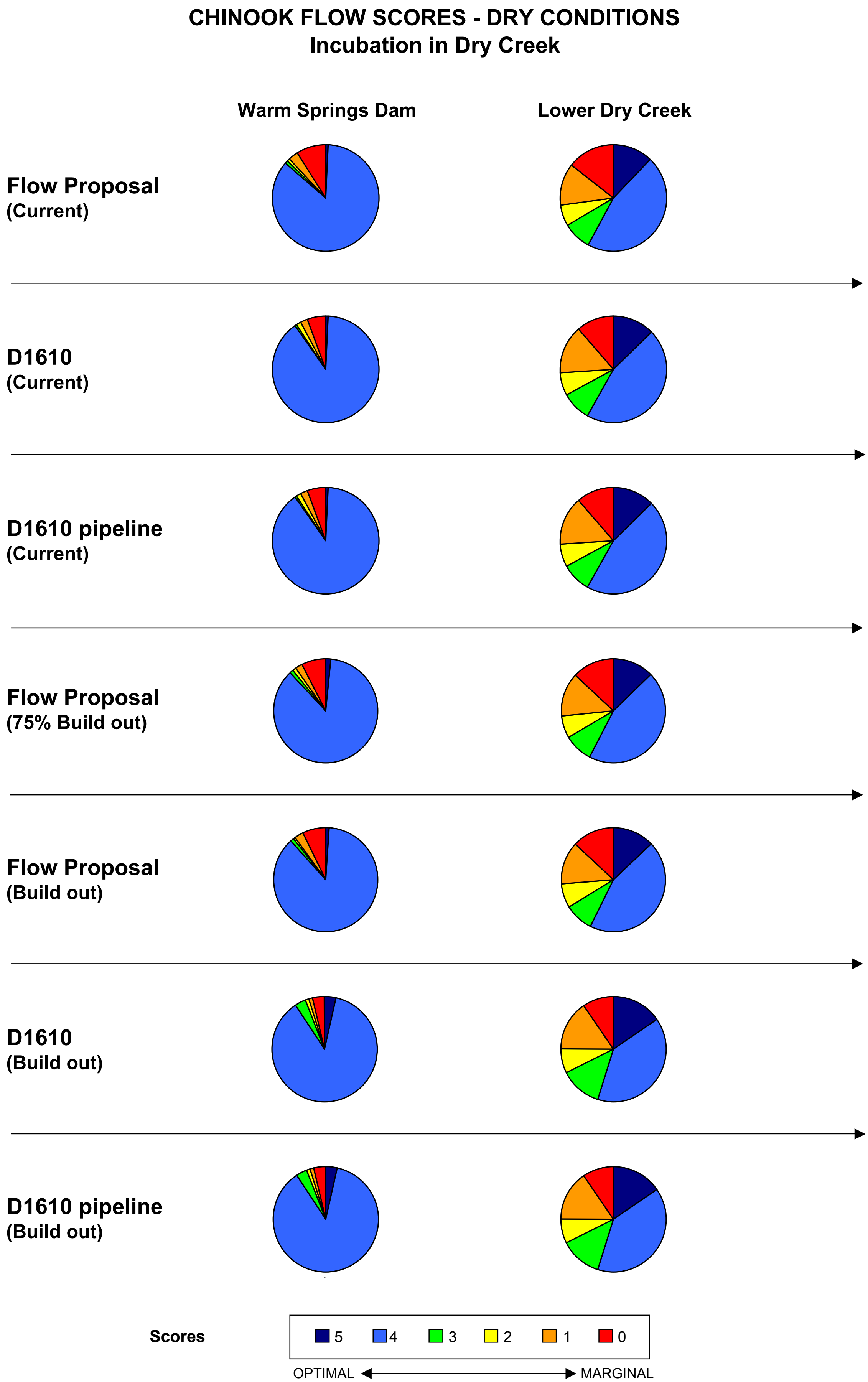

Figure A-40 Chinook Incubation Flow Scores for Dry Water Supply Conditions in Dry Creek

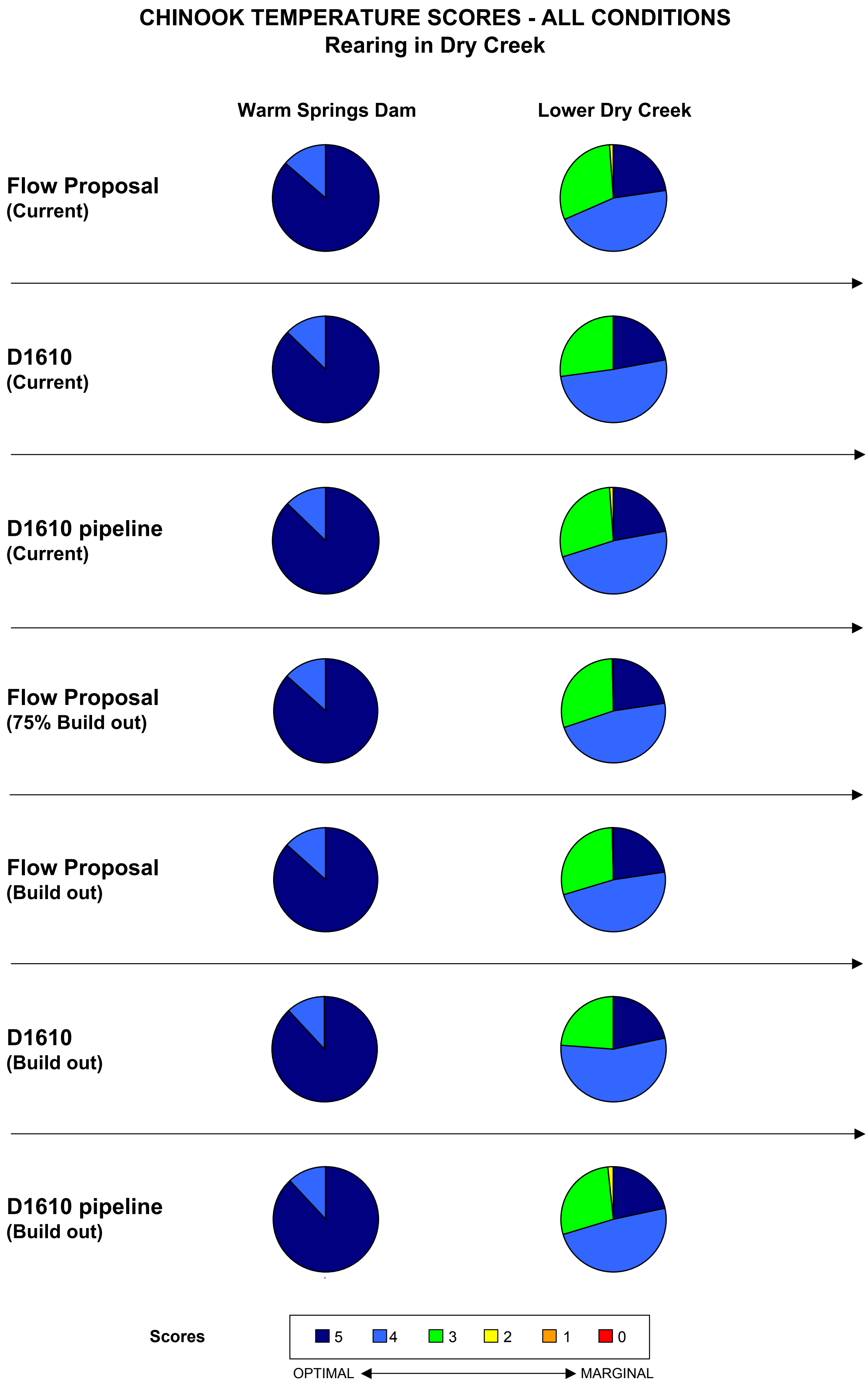

Figure A-41 Chinook Rearing Temperature Scores for All Water Supply Conditions in Dry Creek

CHINOOK TEMPERATURE SCORES - ALL CONDITIONS
Upstream Migration in Dry Creek

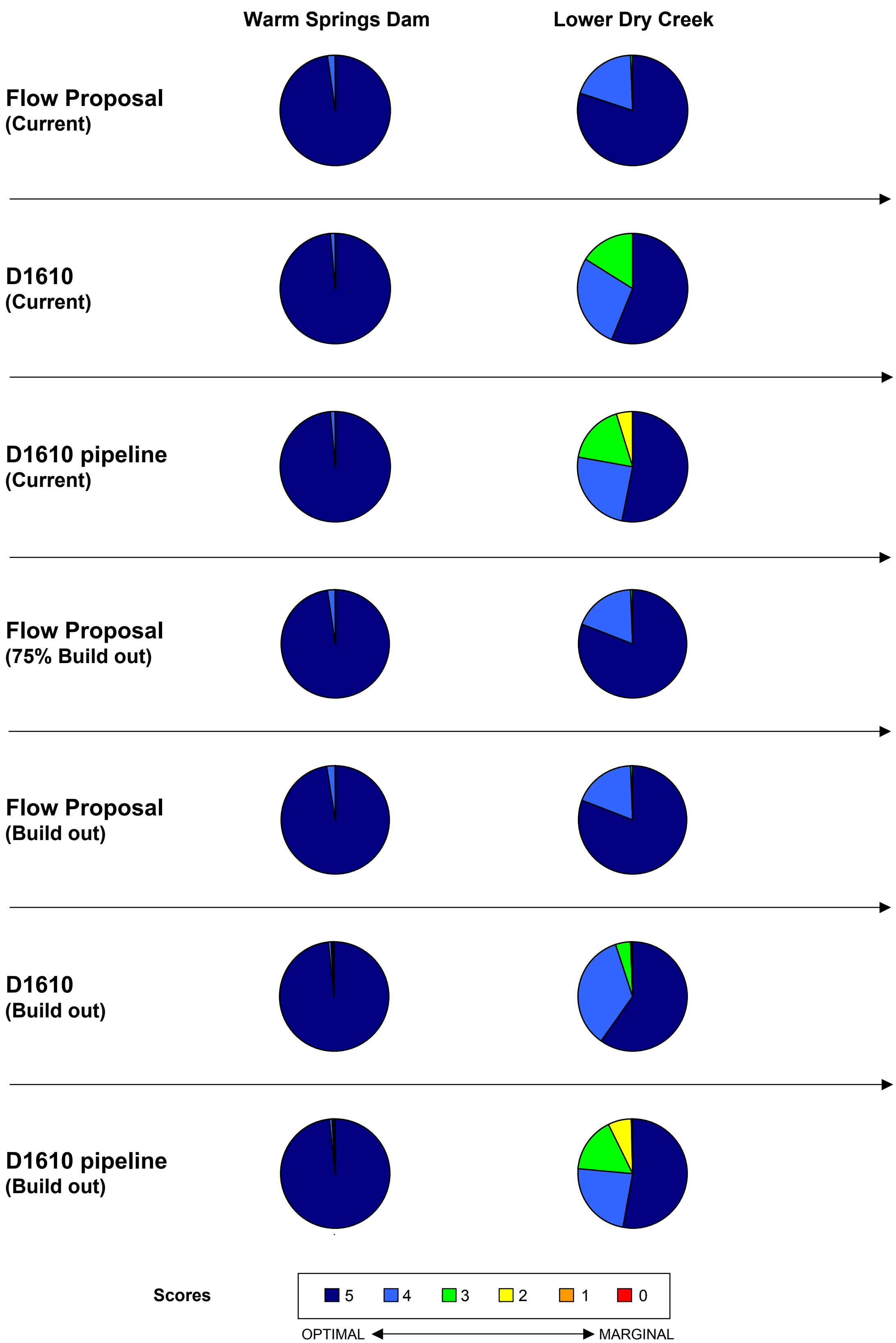

Figure A-42 Chinook Upstream Migration Temperature Scores for All Water Supply Conditions in Dry Creek

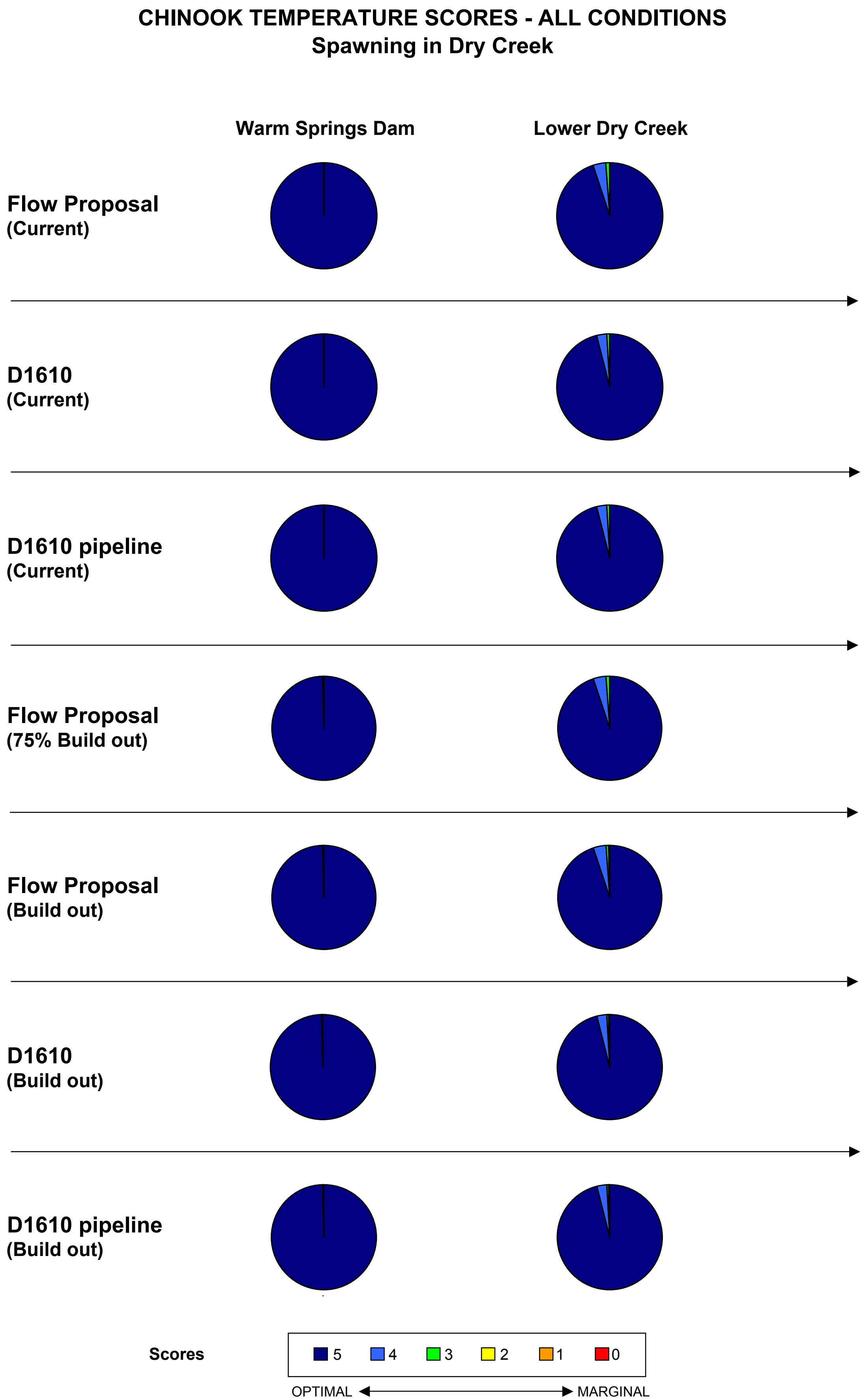

Figure A-43 **Chinook Spawning Temperature Scores for All Water Supply Conditions in Dry Creek**

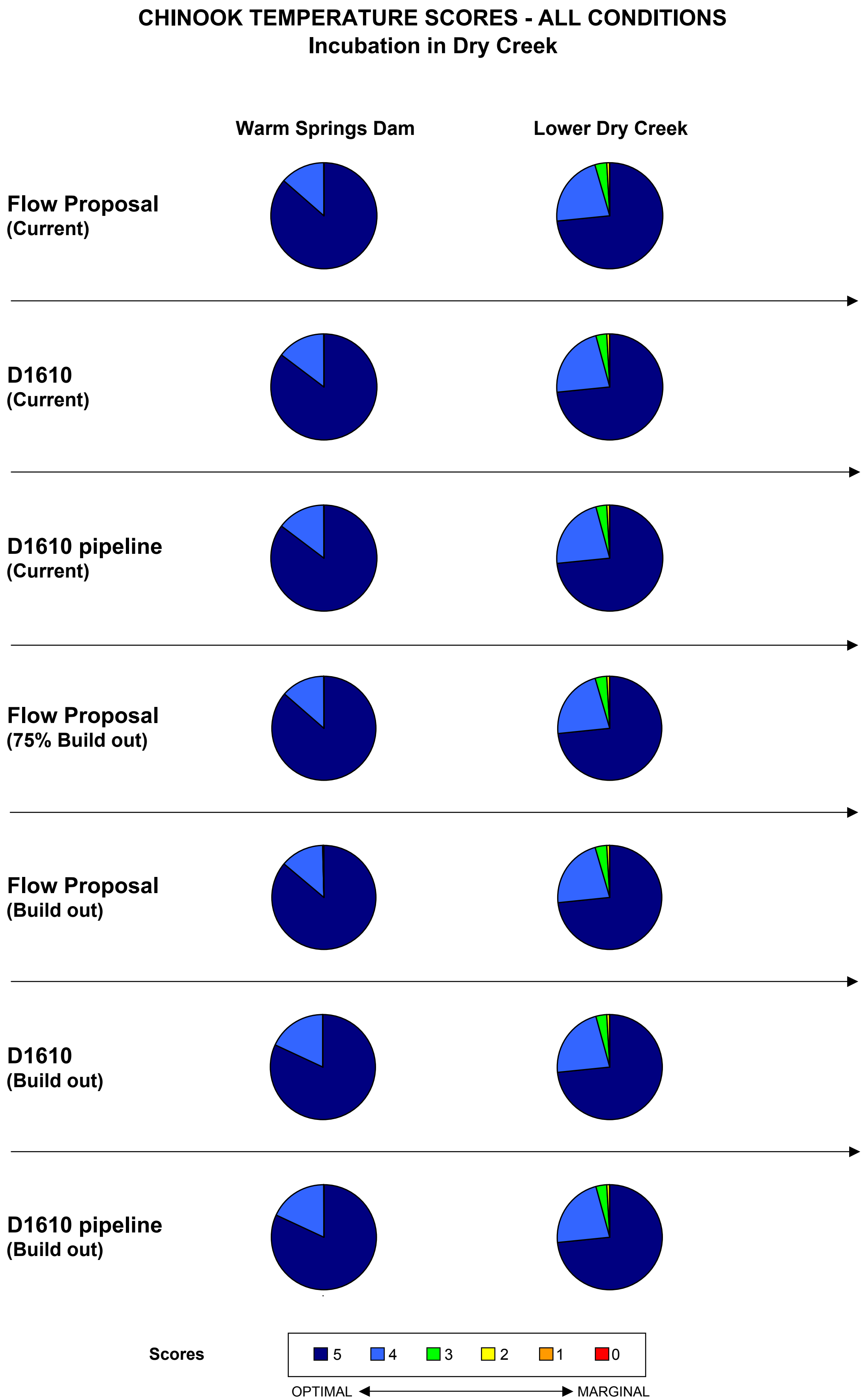

Figure A-44 Chinook Incubation Temperature Scores for All Water Supply Conditions in Dry Creek

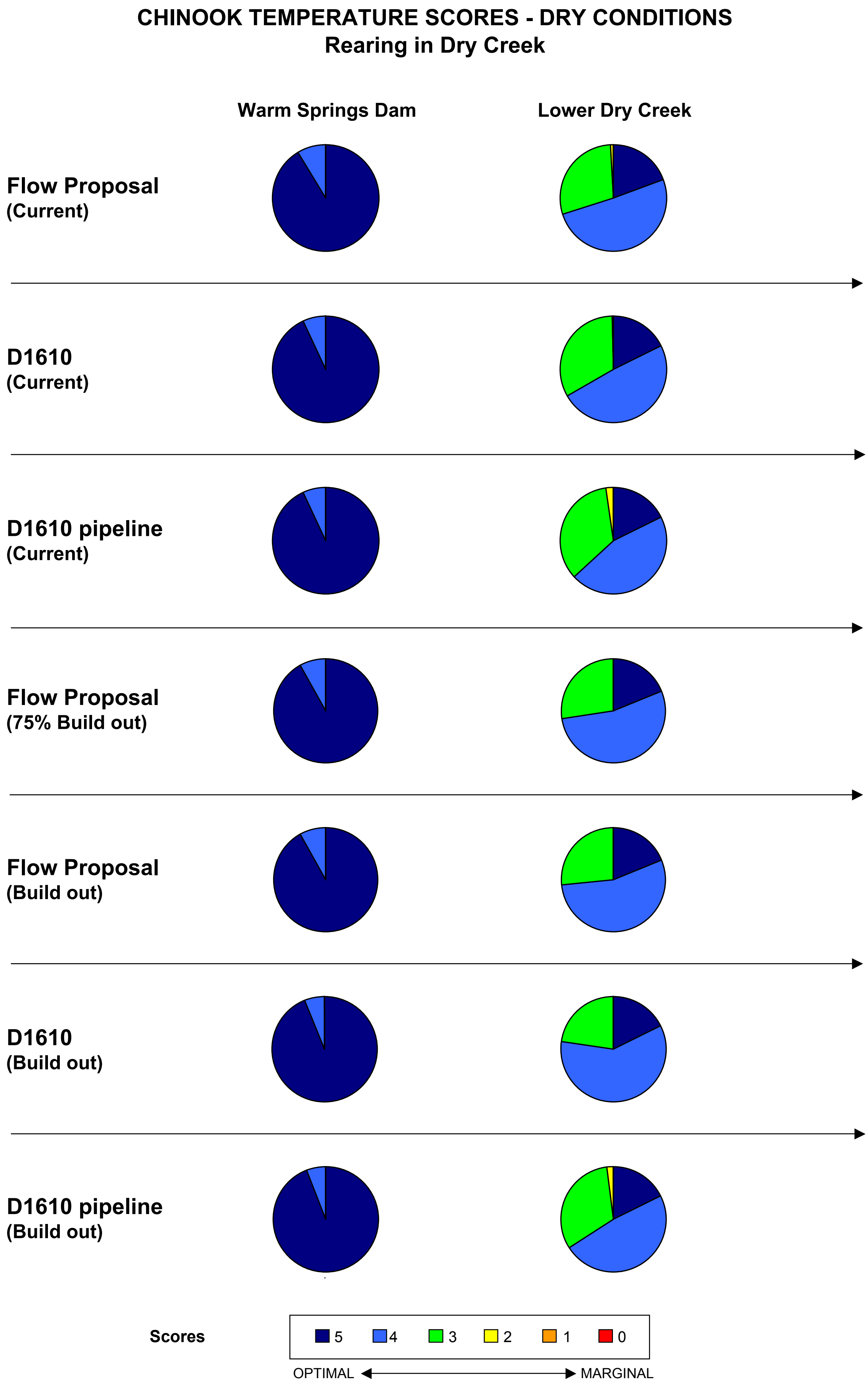

Figure A-45 Chinook Rearing Temperature Scores for Dry Water Supply Conditions in Dry Creek

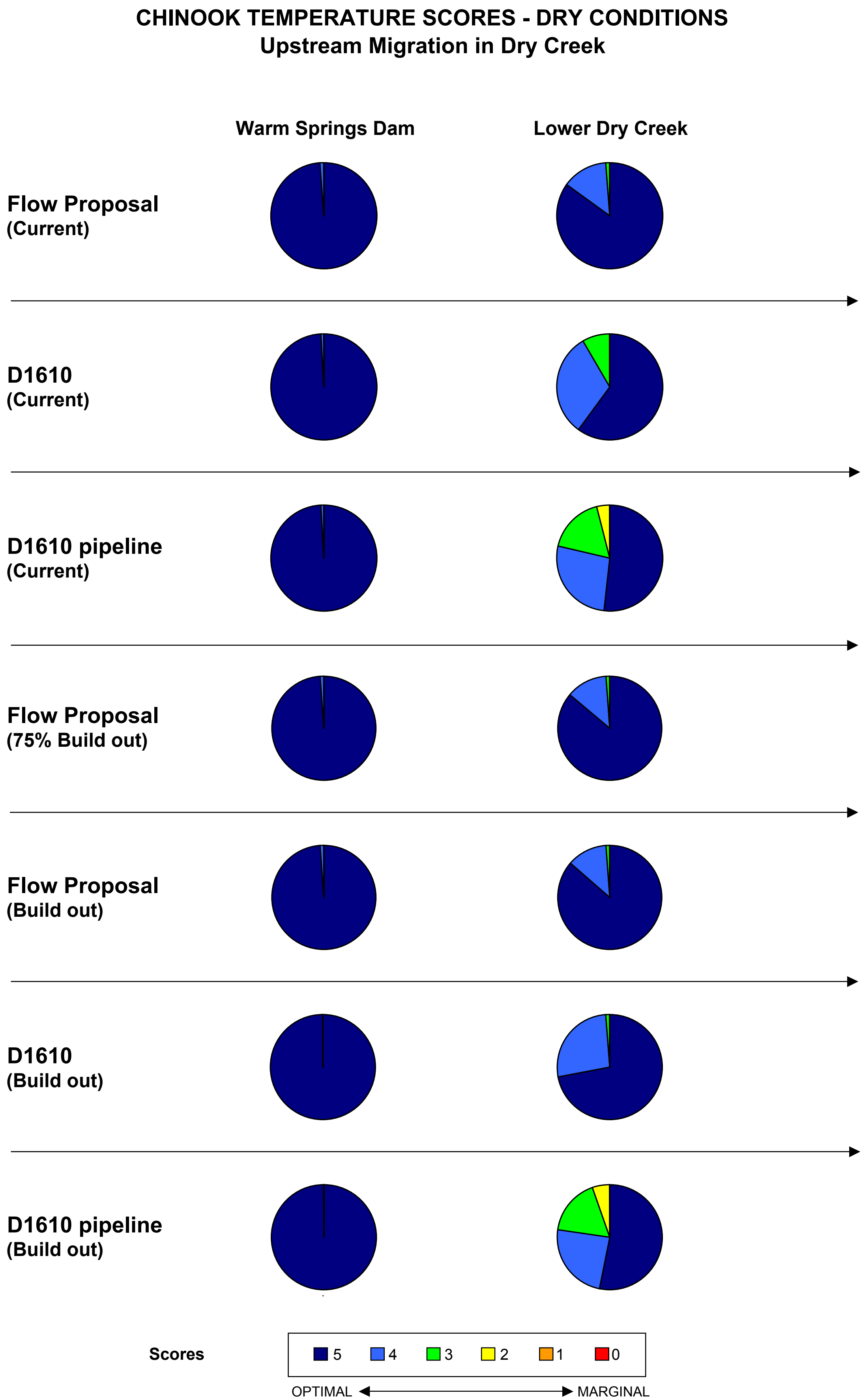

Figure A-46 Chinook Upstream Migration Temperature Scores for Dry Water Supply Conditions in Dry Creek

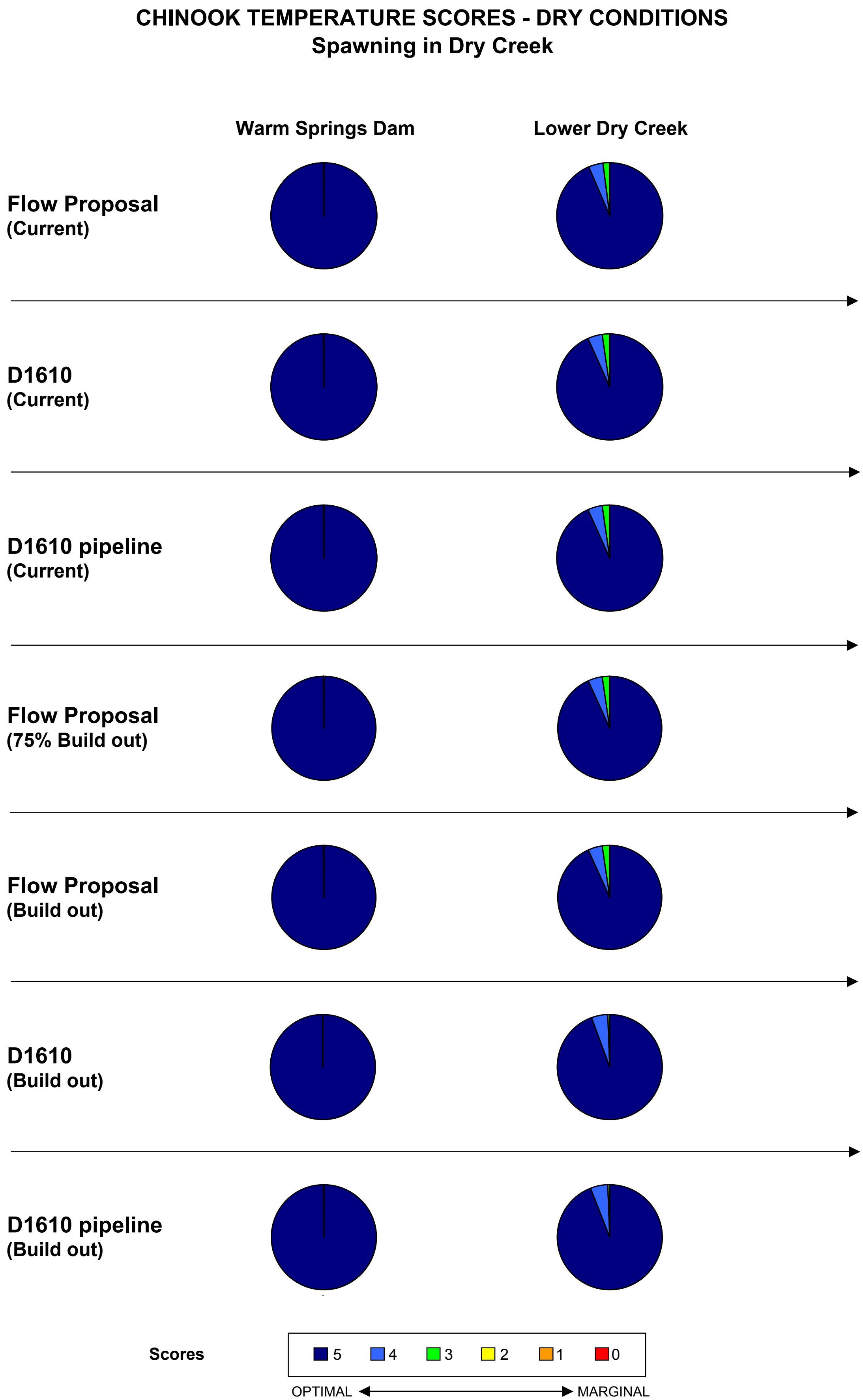

Figure A-47 Chinook Spawning Temperature Scores for Dry Water Supply Conditions in Dry Creek

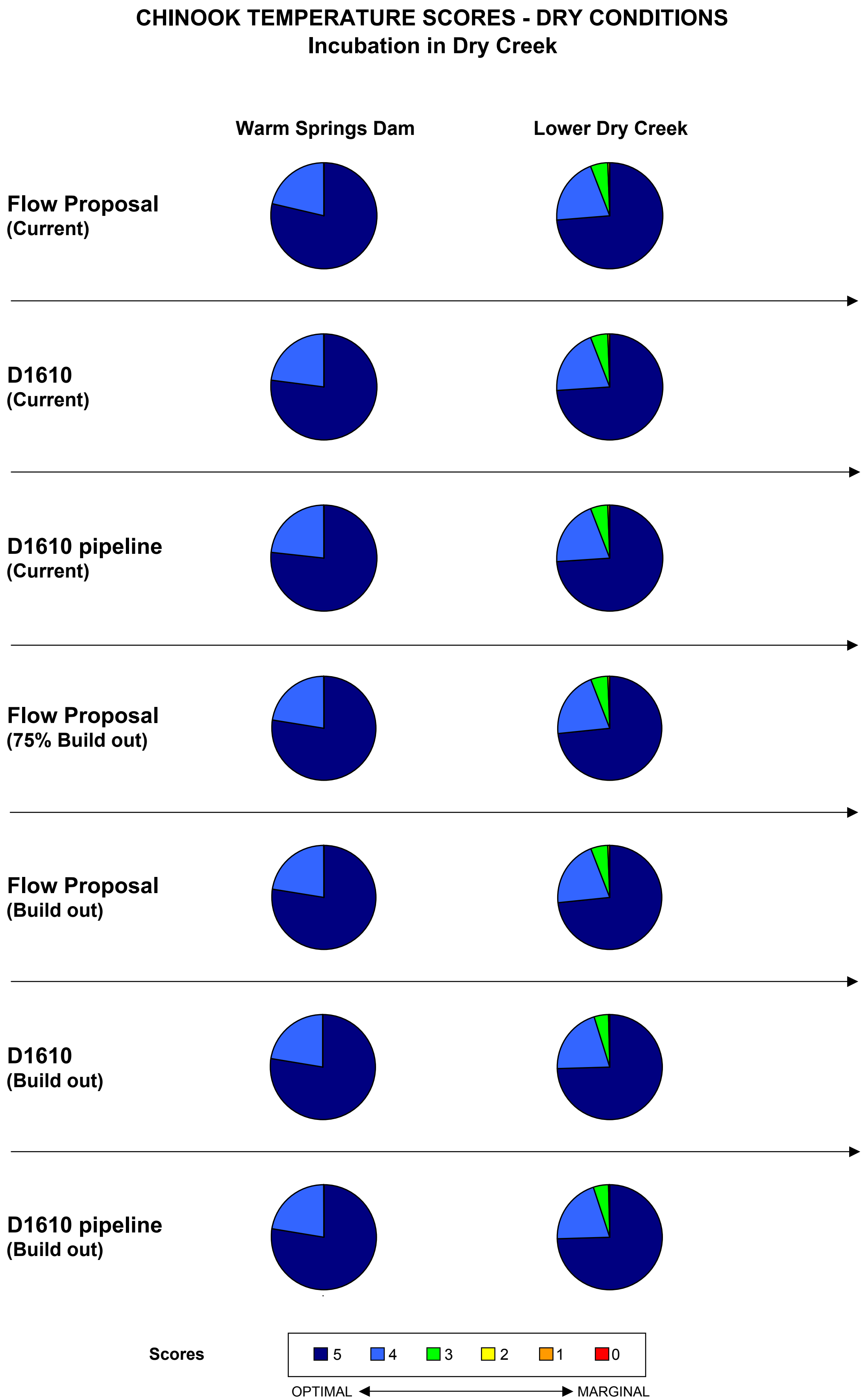

Figure A-48 Chinook Incubation Temperature Scores for Dry Water Supply Conditions in Dry Creek

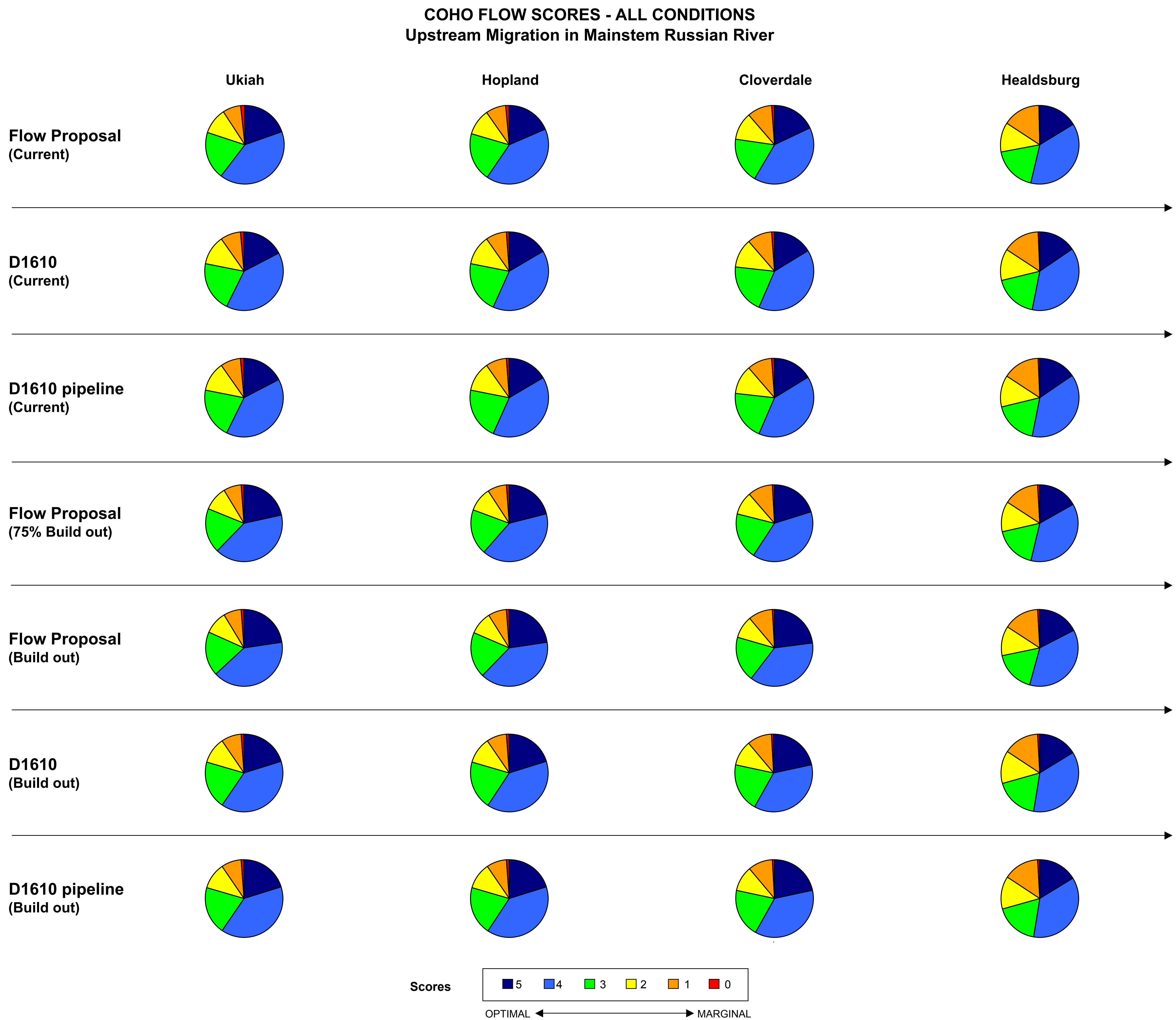

Figure A-49 Coho Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

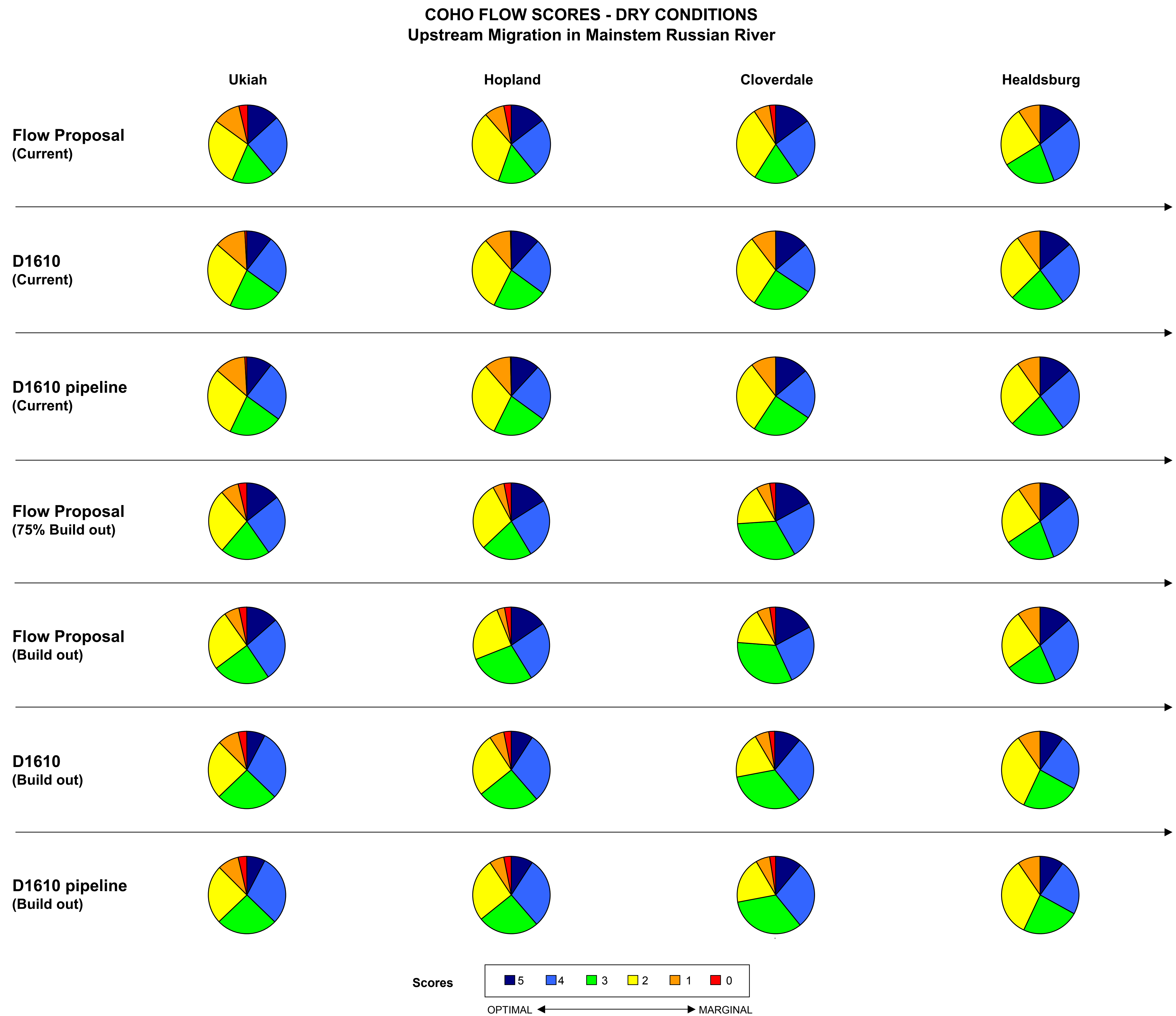

Figure A-50 Coho Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

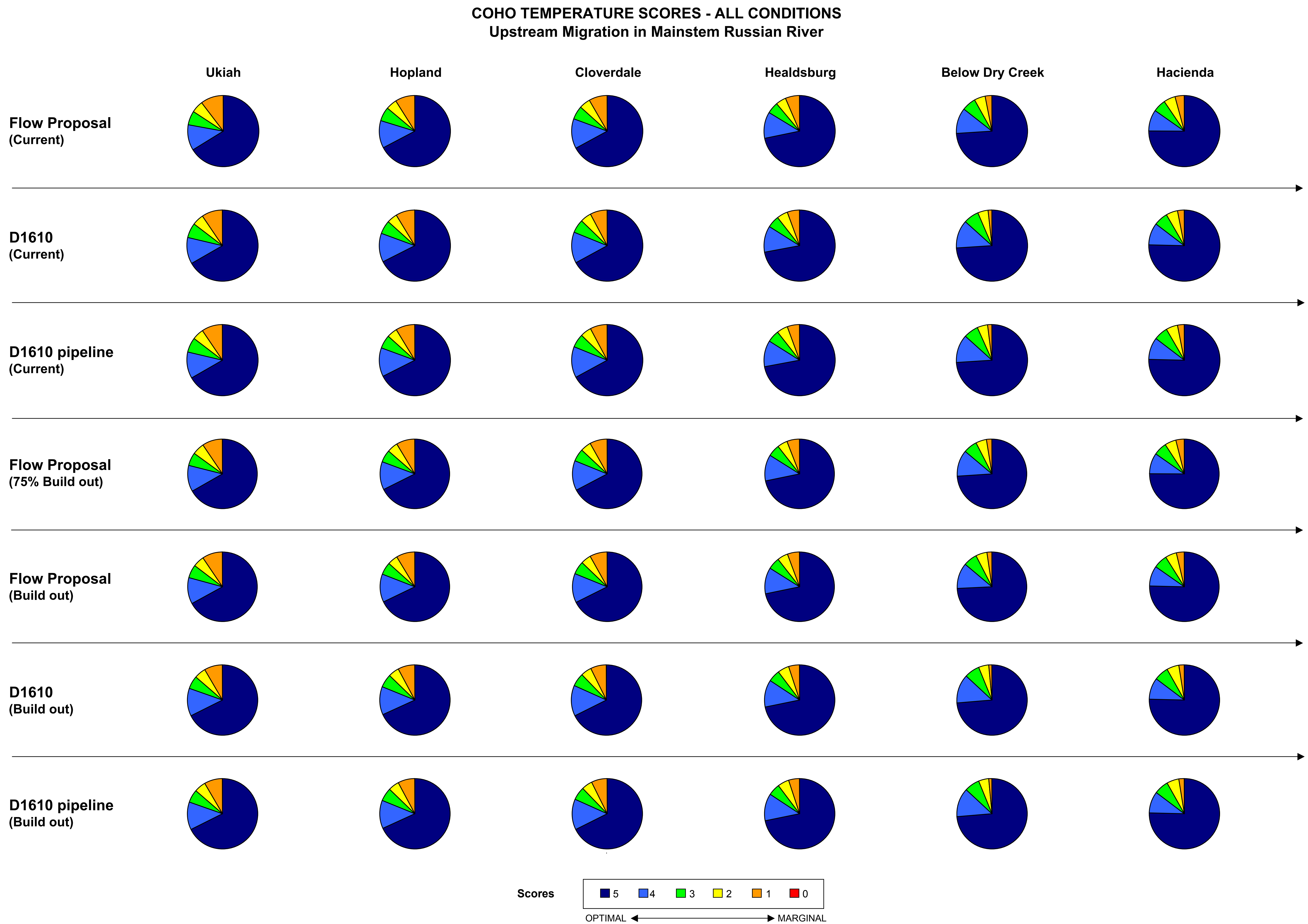

Figure A-51 Coho Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

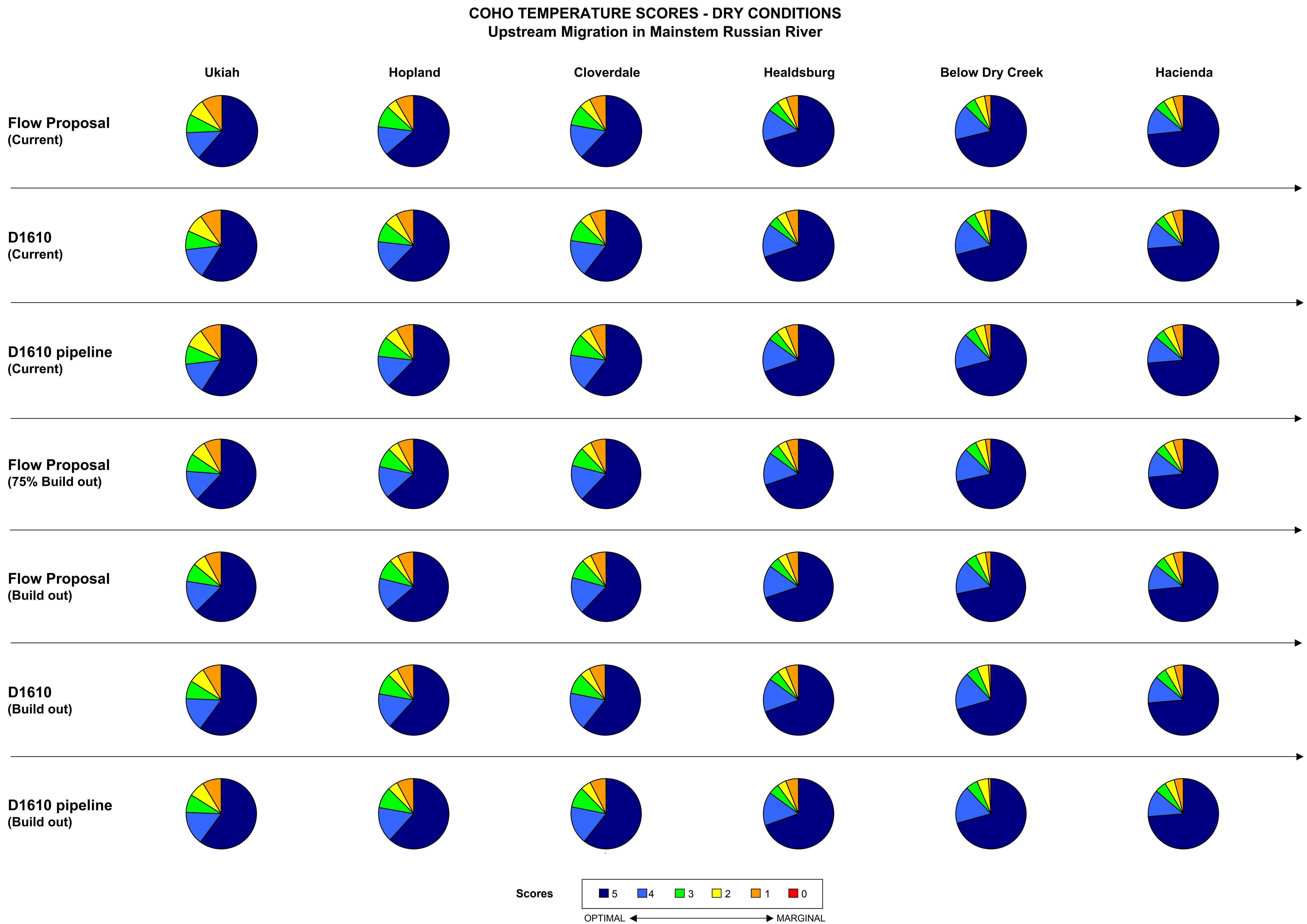

Figure A-52 Coho Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

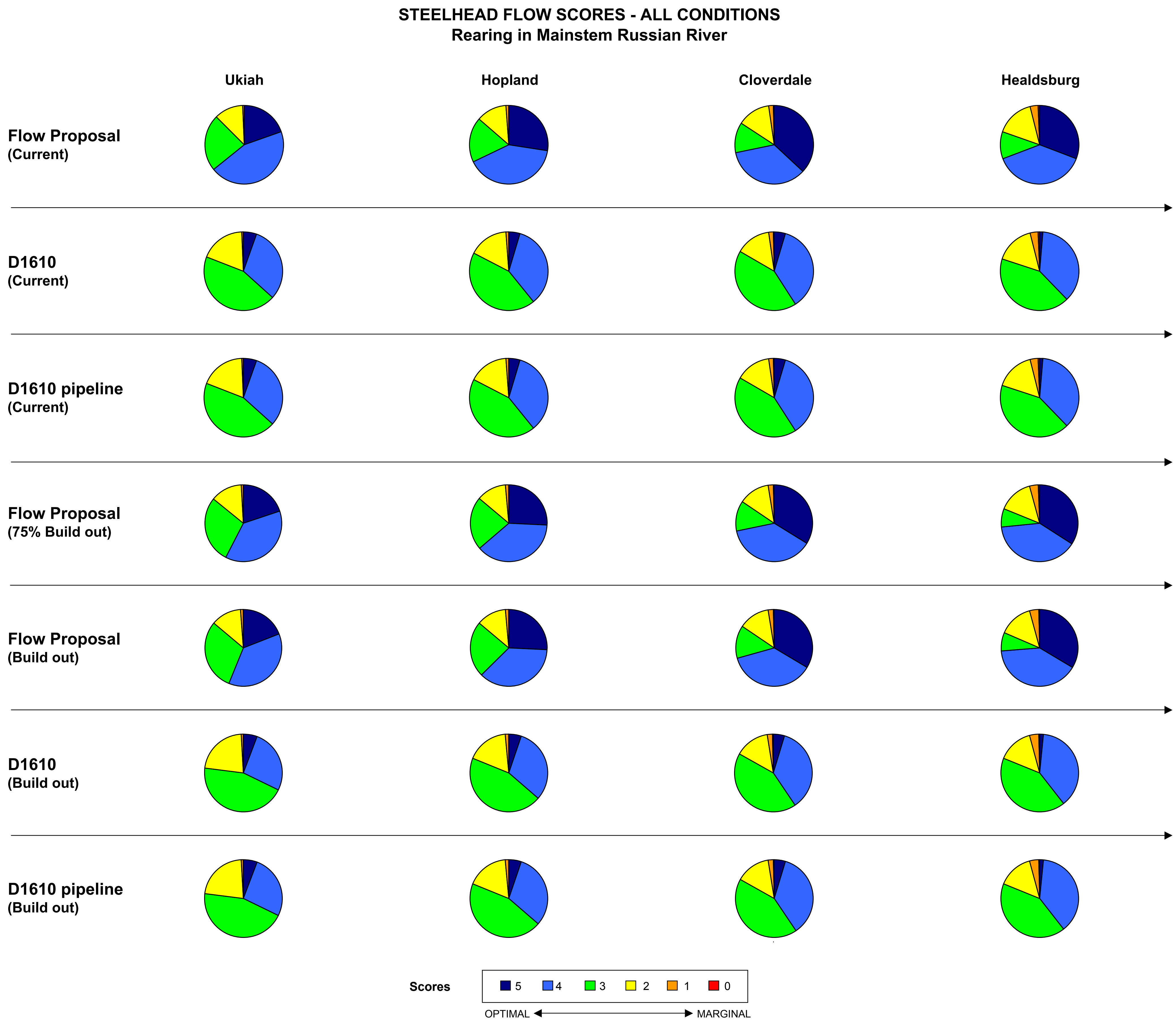

Figure A-53 Steelhead Rearing Flow Scores for All Water Supply Conditions in the Russian River

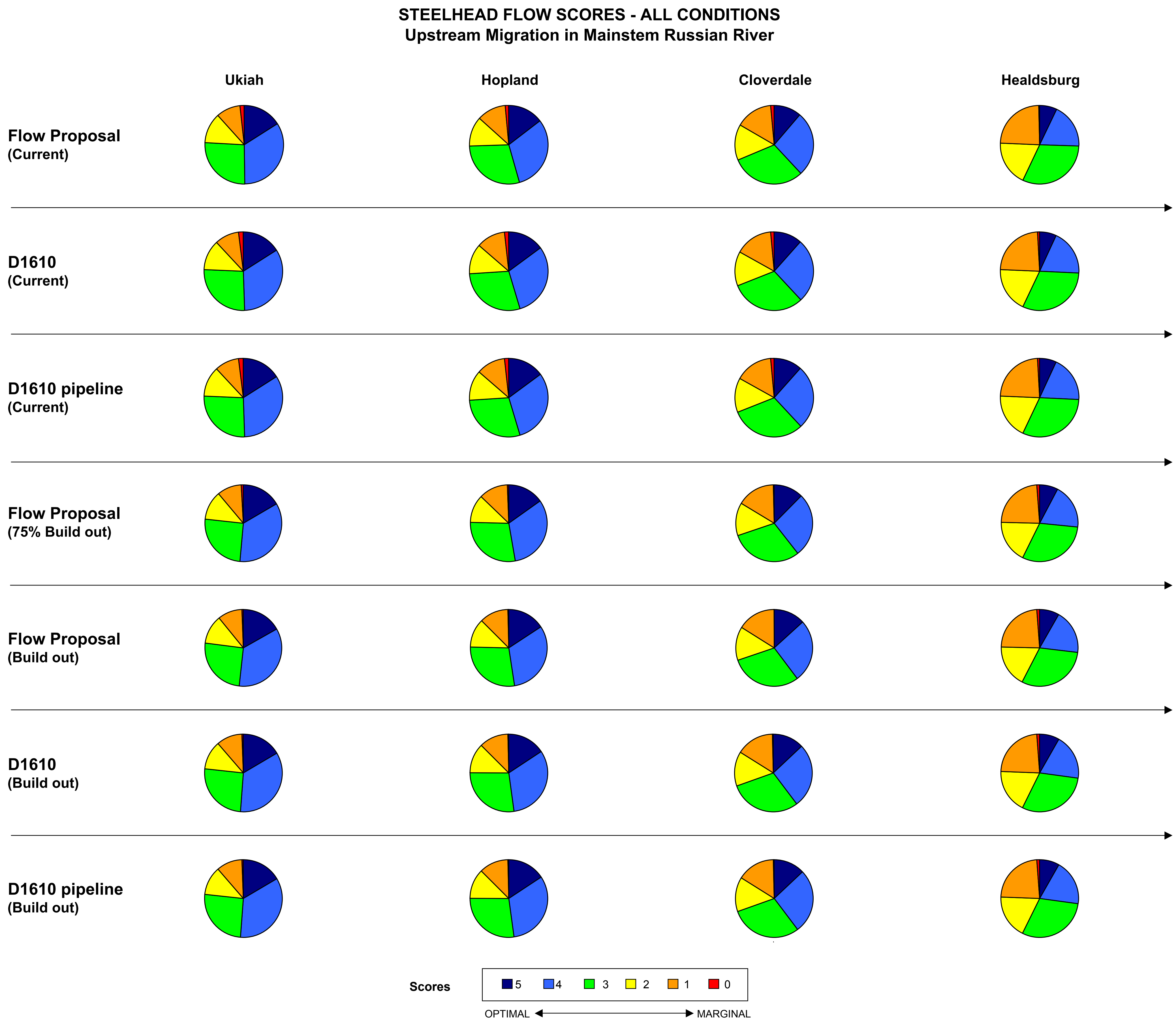

Figure A-54 Steelhead Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

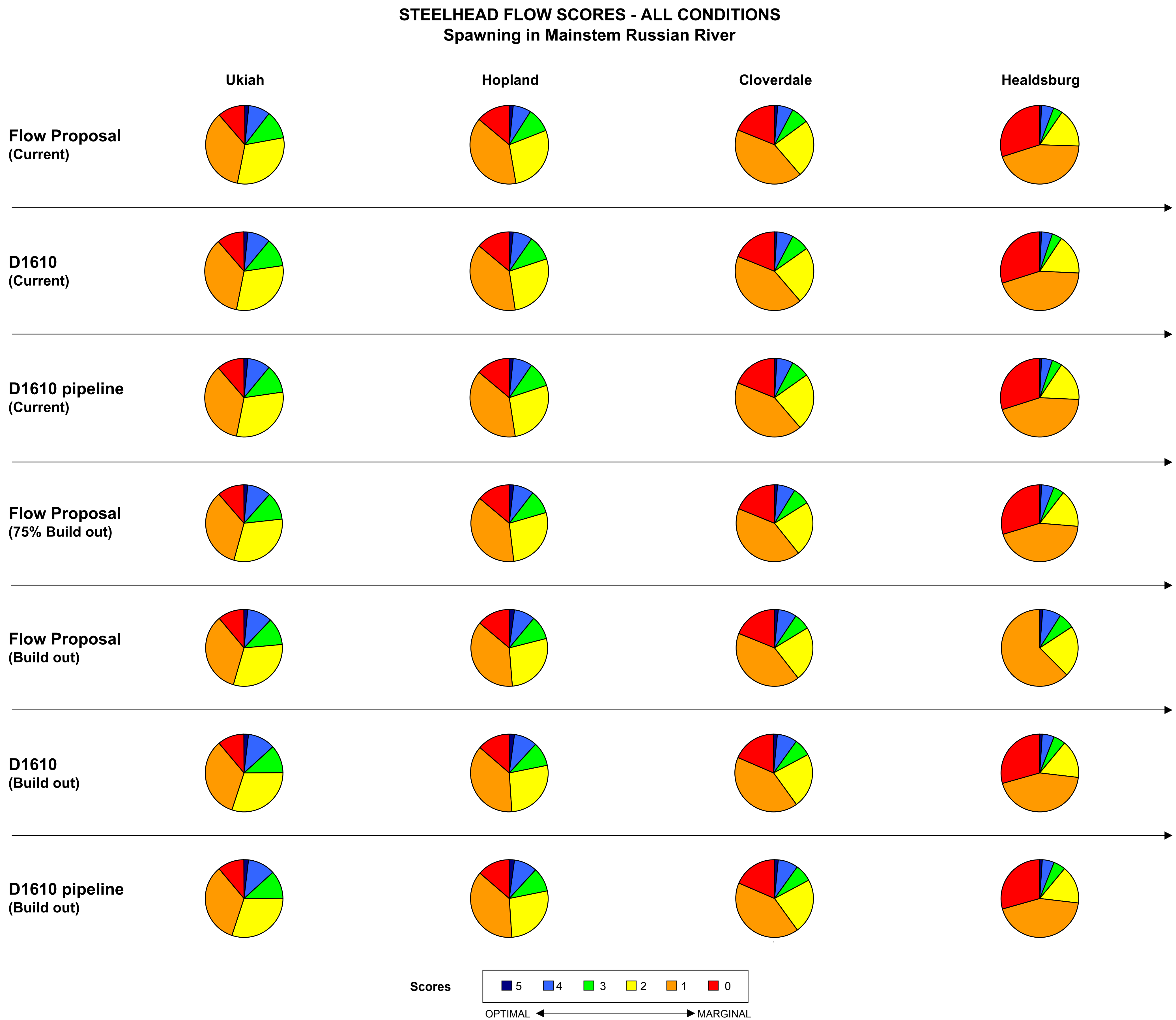

Figure A-55 Steelhead Spawning Flow Scores for All Water Supply Conditions in the Russian River

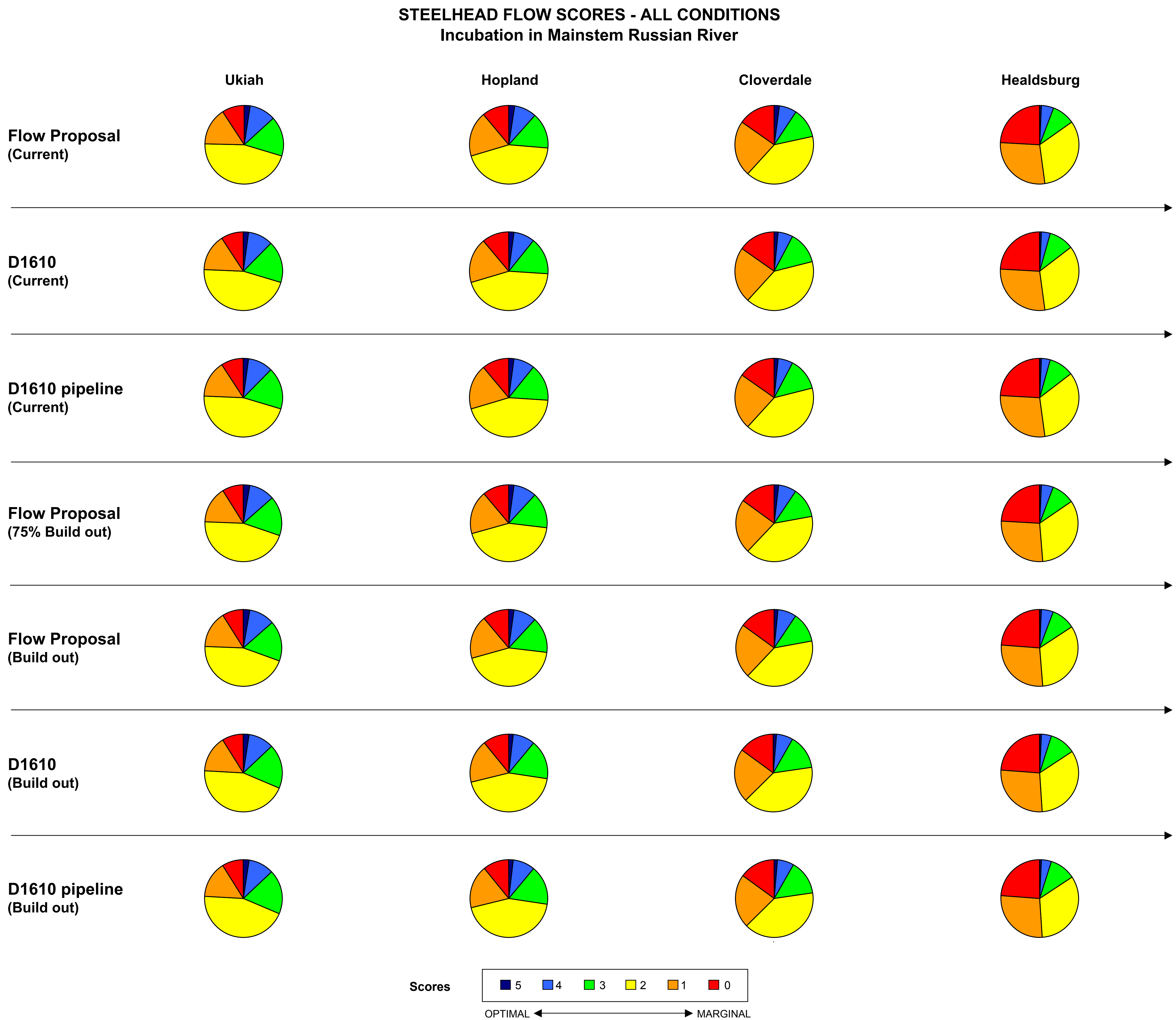

Figure A-56 Steelhead Incubation Flow Scores for All Water Supply Conditions in the Russian River

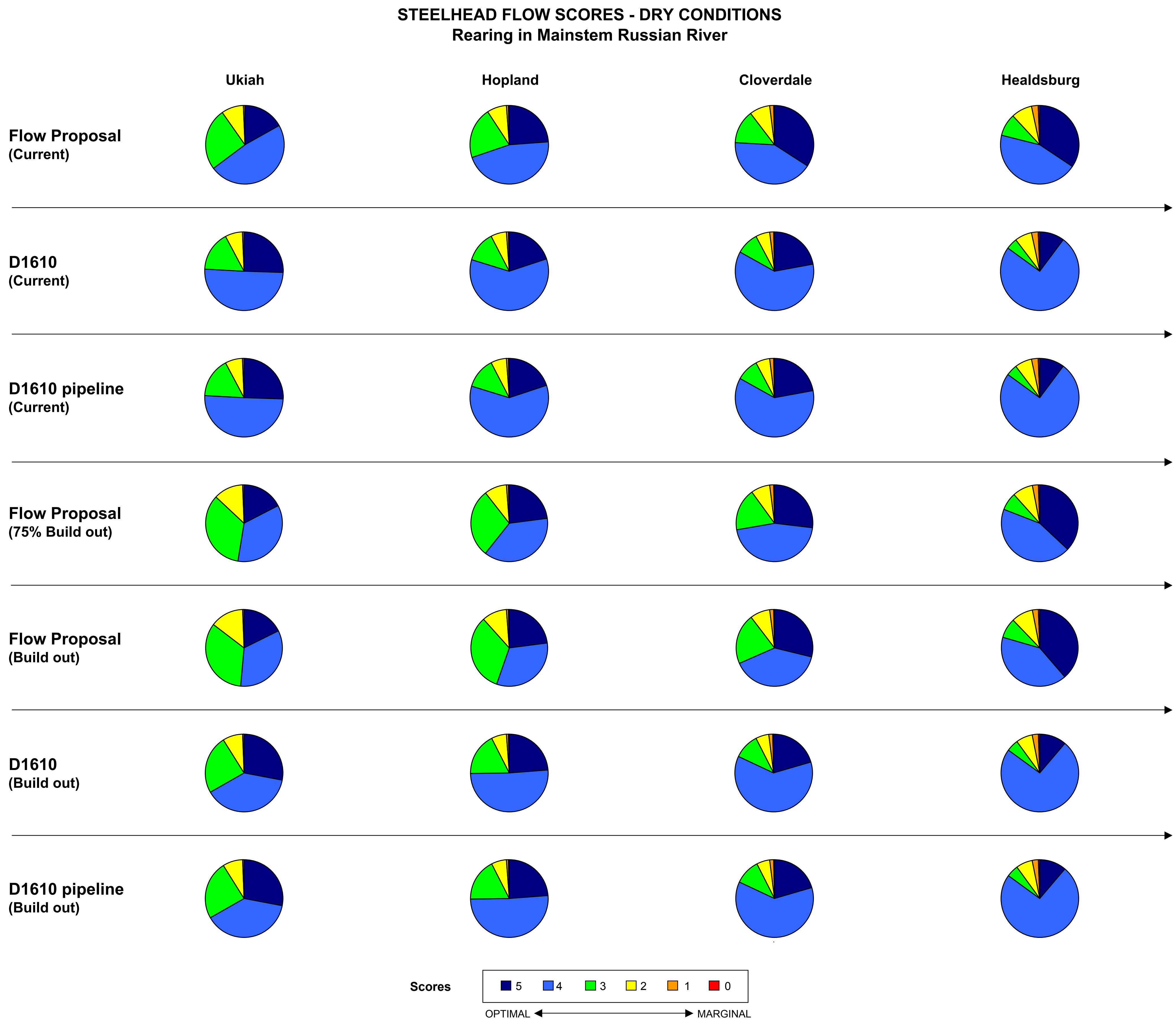

Figure A-57 Steelhead Rearing Flow Scores for Dry Water Supply Conditions in the Russian River

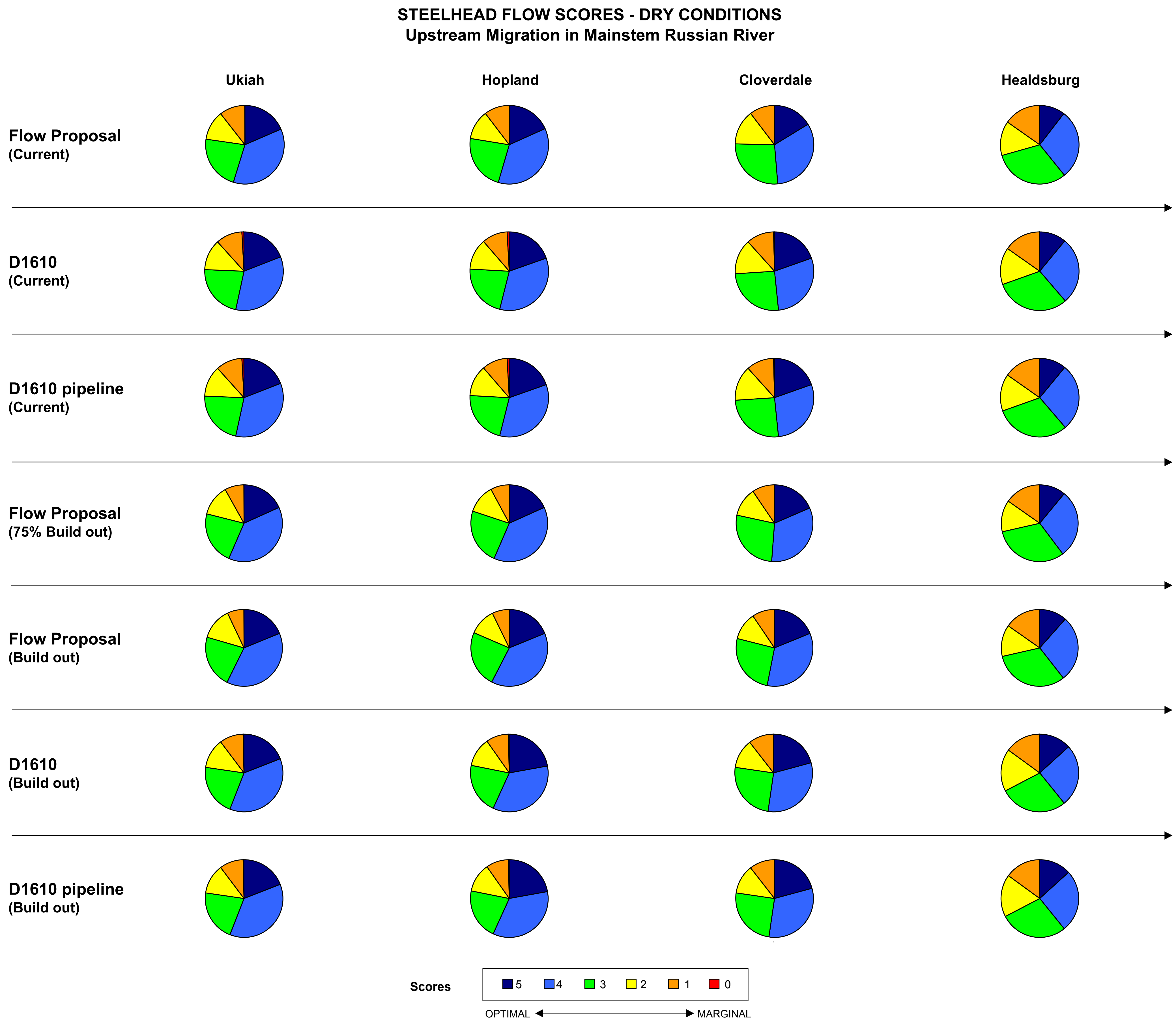

Figure A-58 Steelhead Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

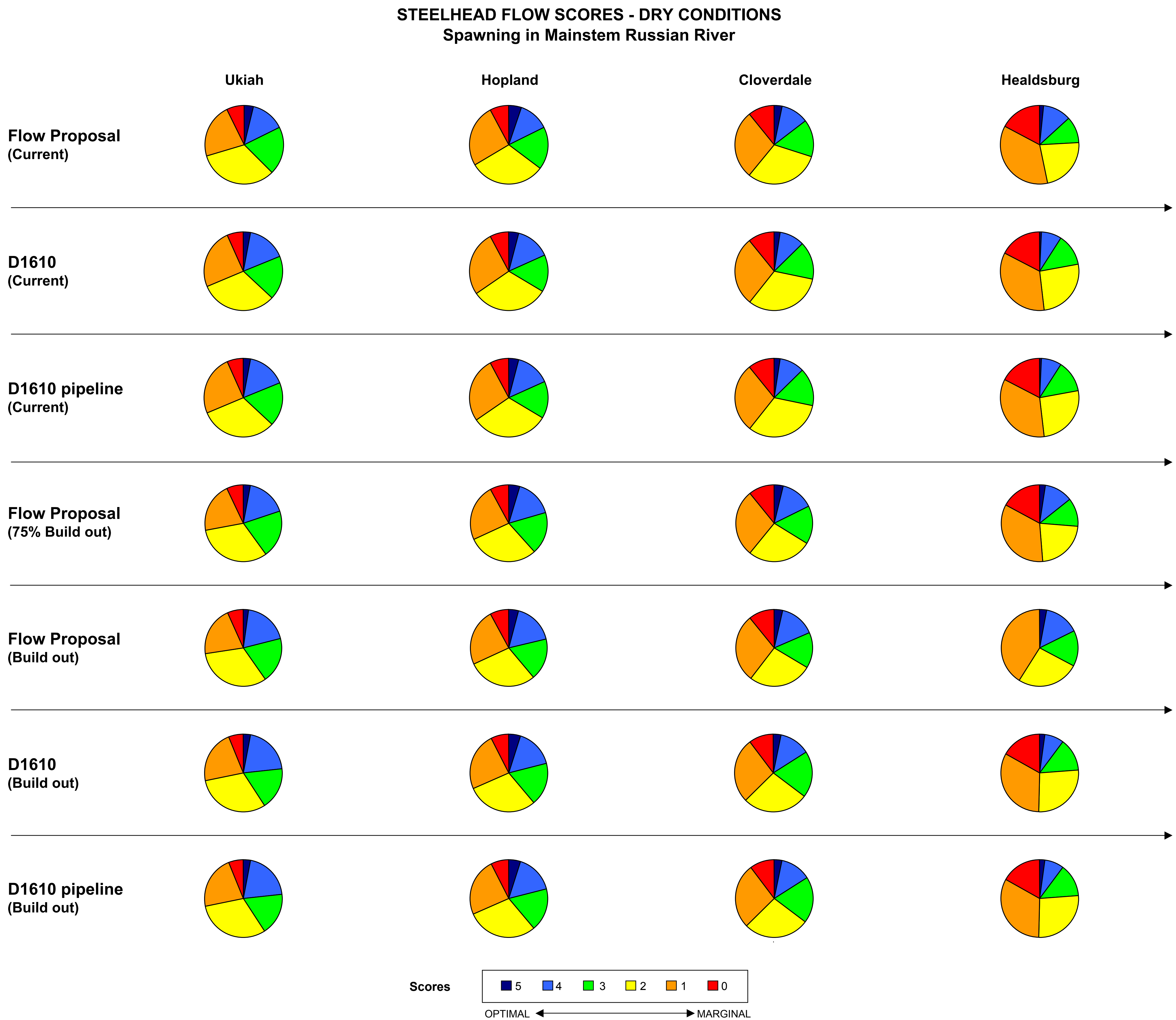

Figure A-59 Steelhead Spawning Flow Scores for Dry Water Supply Conditions in the Russian River

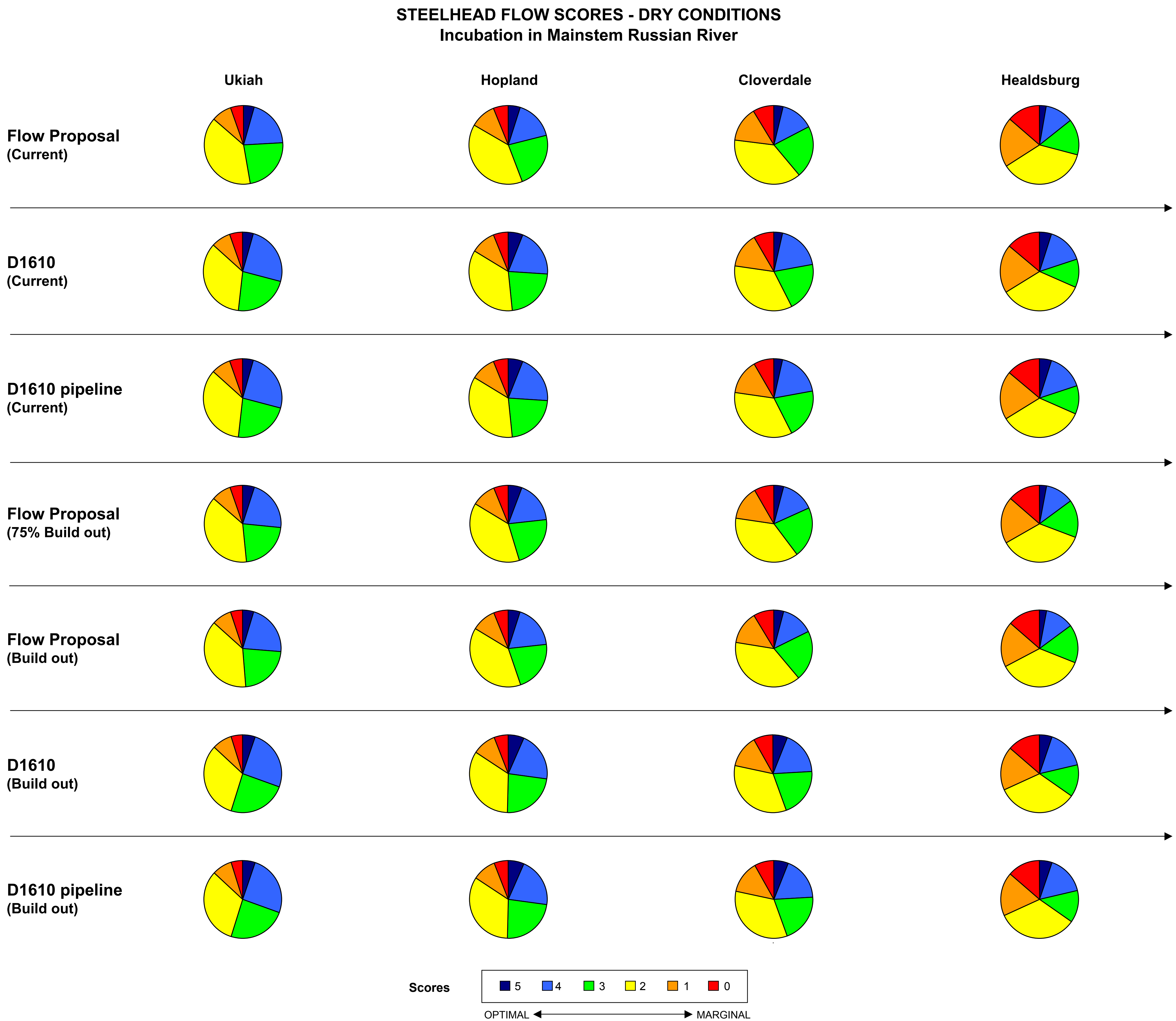

Figure A-60 **Steelhead Incubation Flow Scores for Dry Water Supply Conditions in the Russian River**

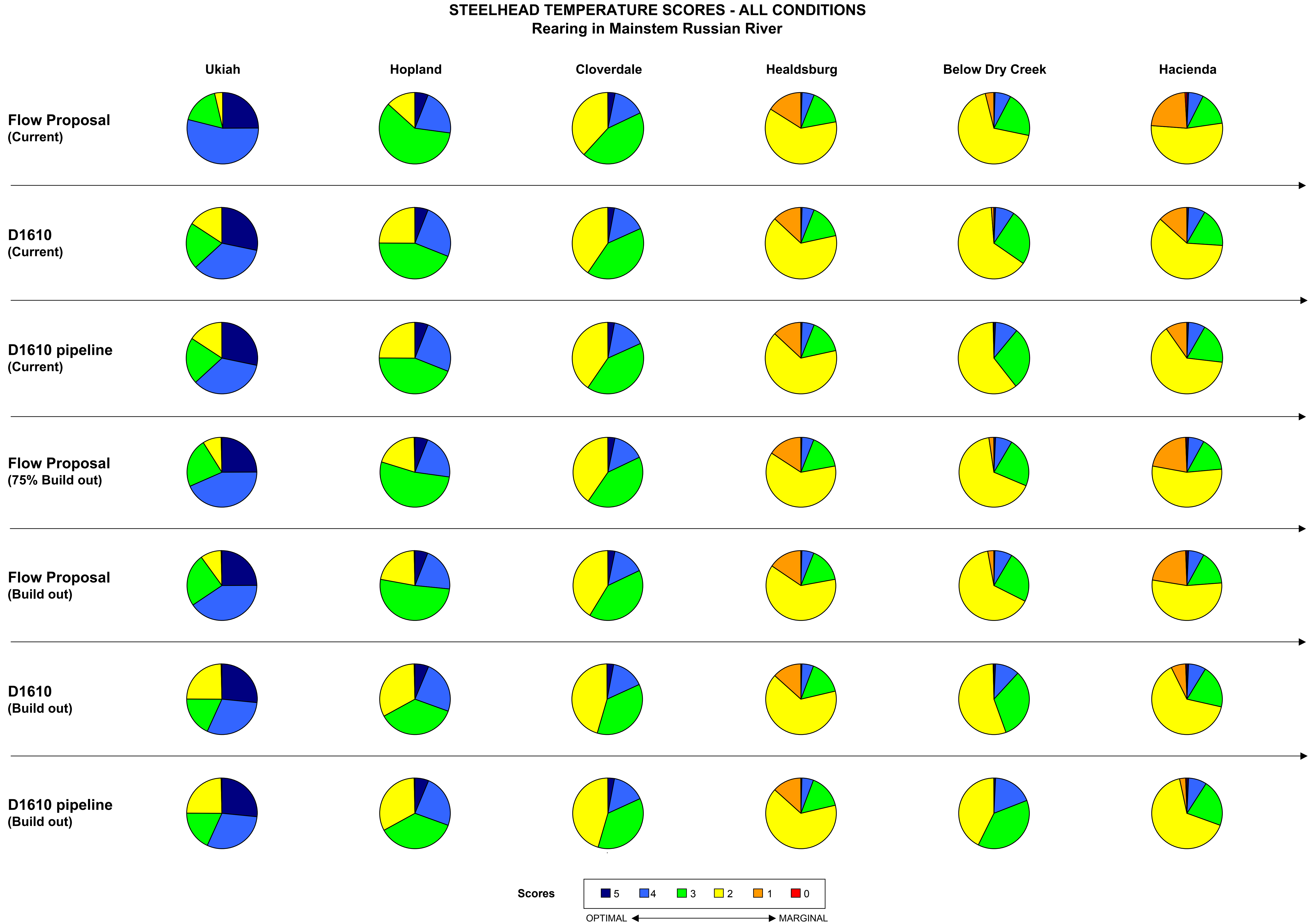

Figure A-61 Steelhead Rearing Temperature Scores for All Water Supply Conditions in the Russian River

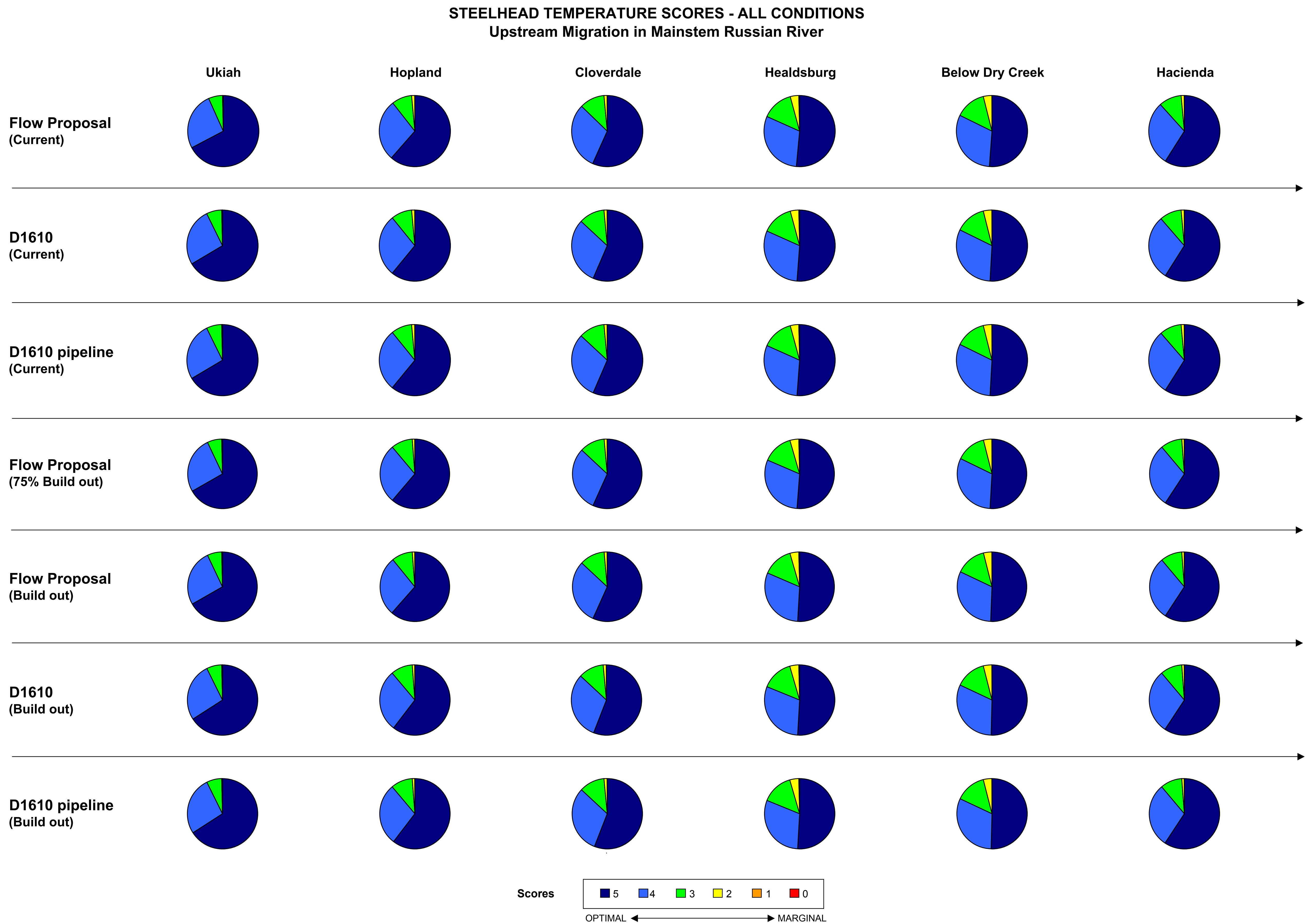

Figure A-62 Steelhead Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

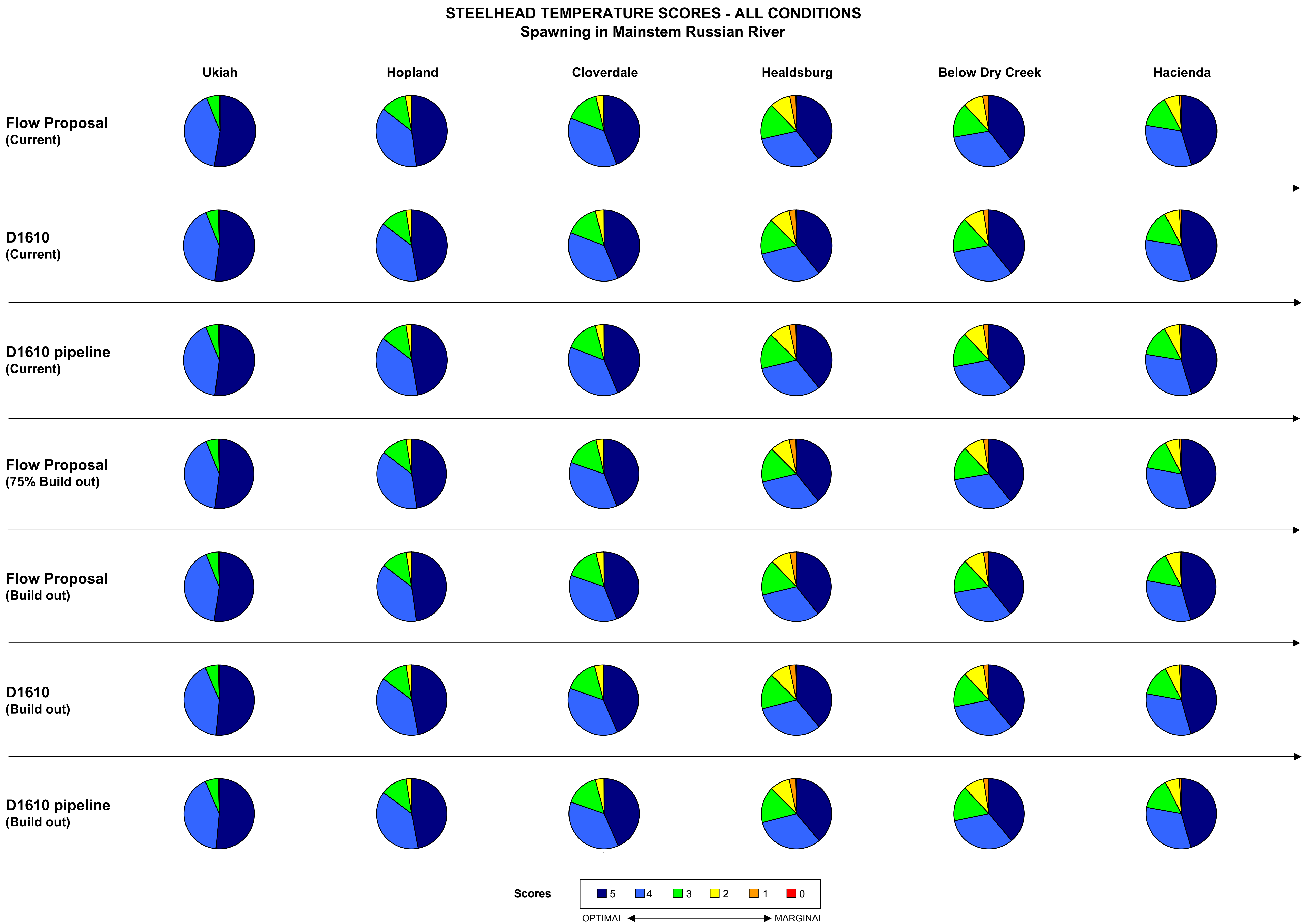

Figure A-63 Steelhead Spawning Temperature Scores for All Water Supply Conditions in the Russian River

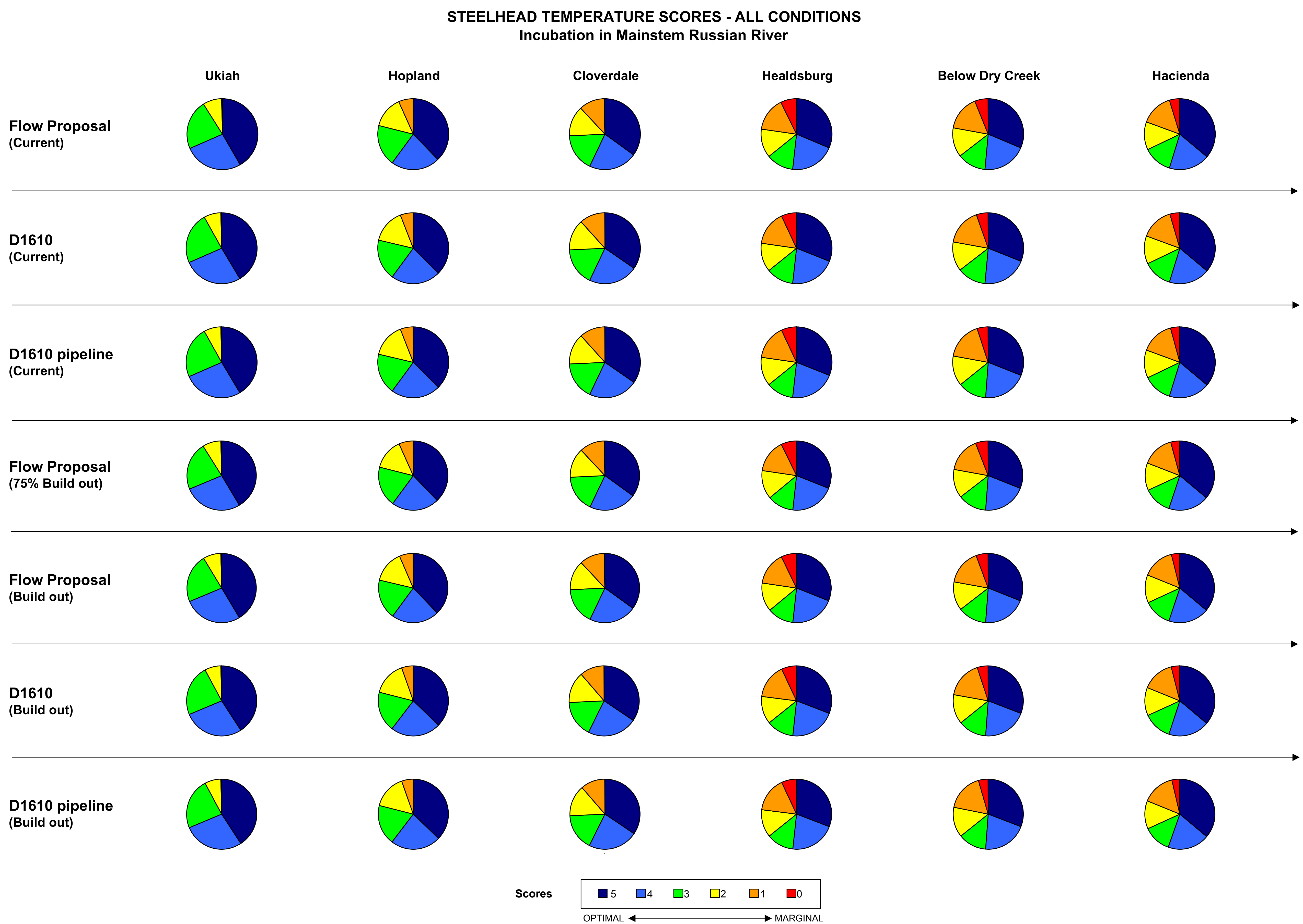

Figure A-64 Steelhead Incubation Temperature Scores for All Water Supply Conditions in the Russian River

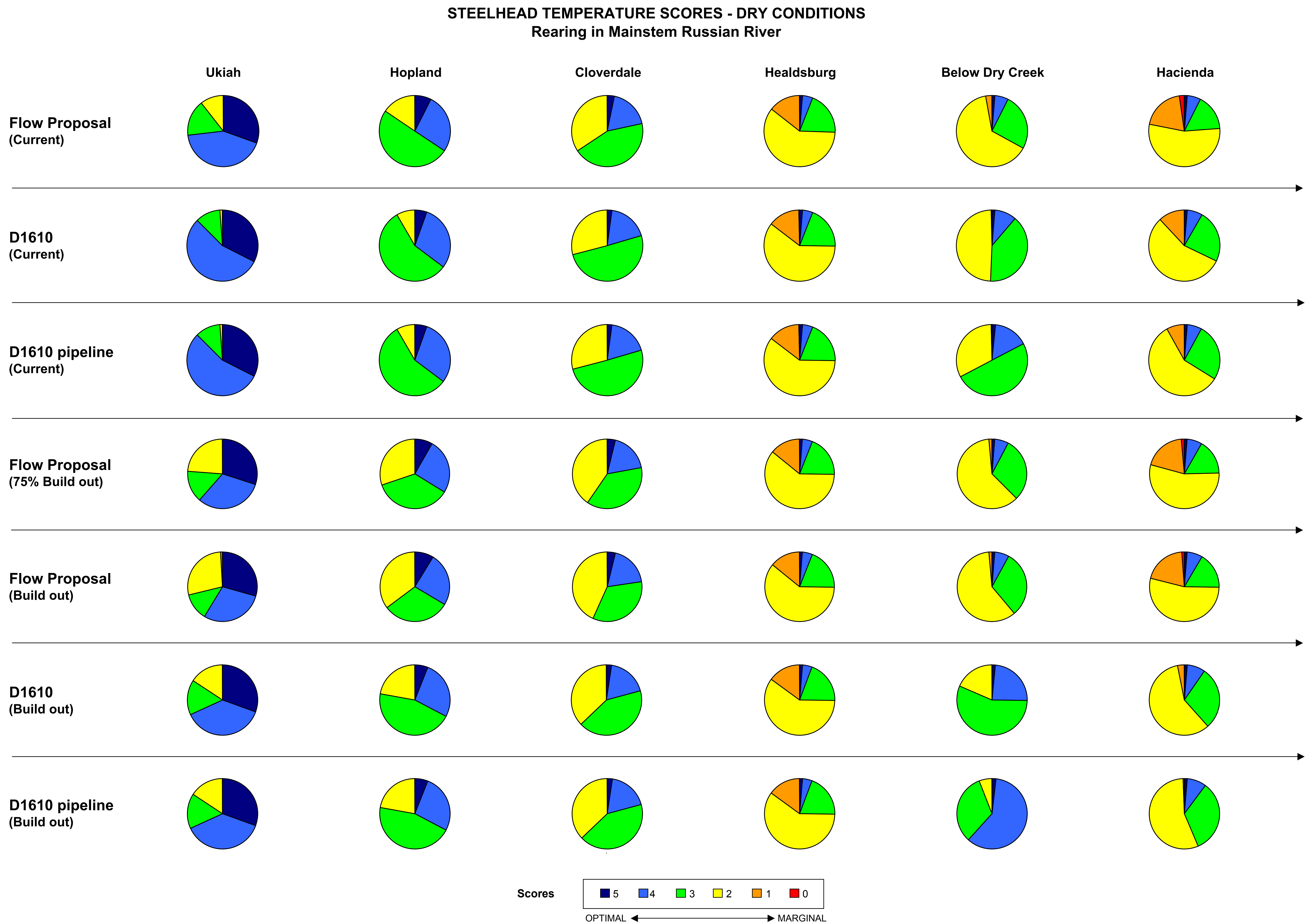

Figure A-65 Steelhead Rearing Temperature Scores for Dry Water Supply Conditions in the Russian River

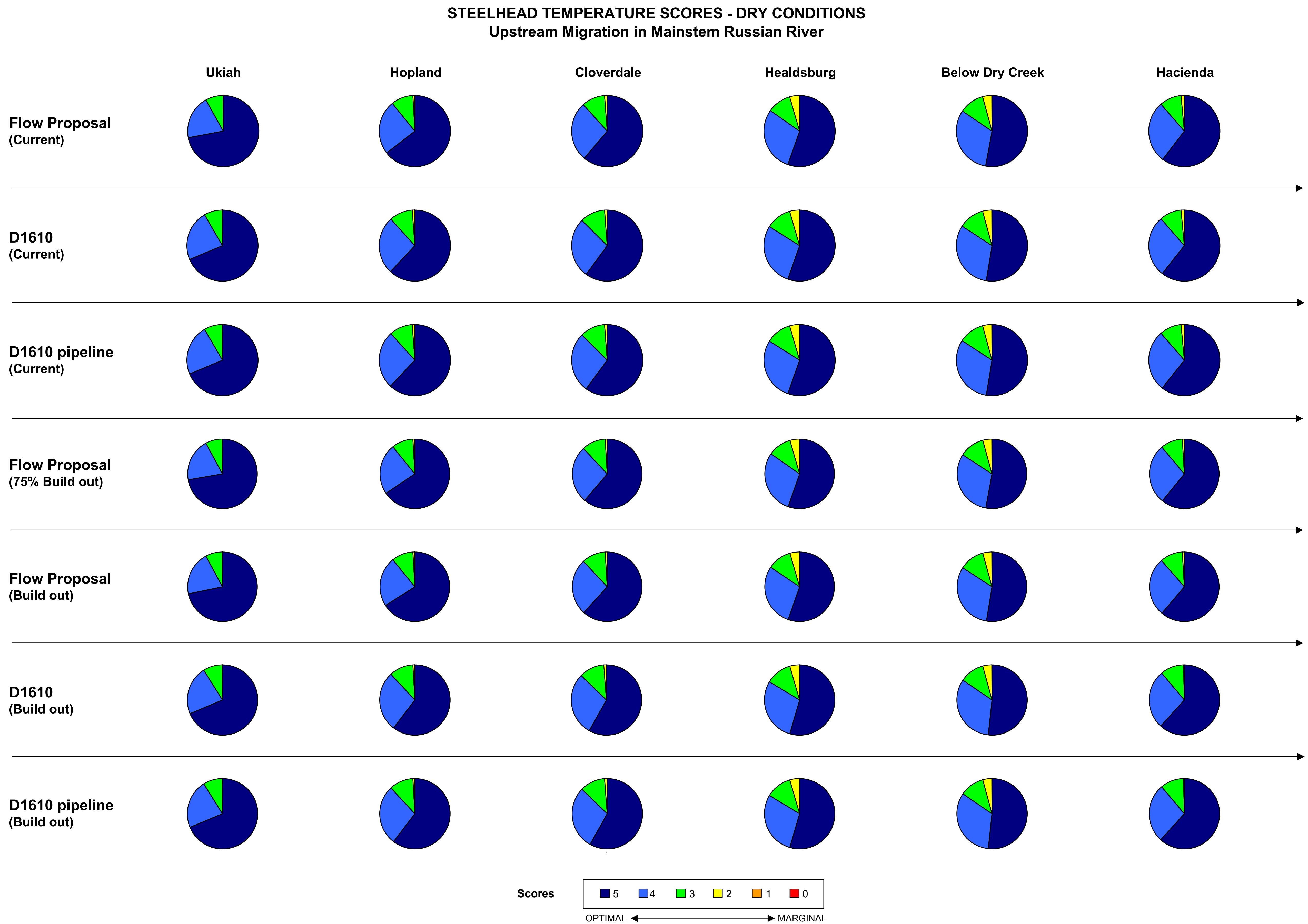

Figure A-66 Steelhead Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

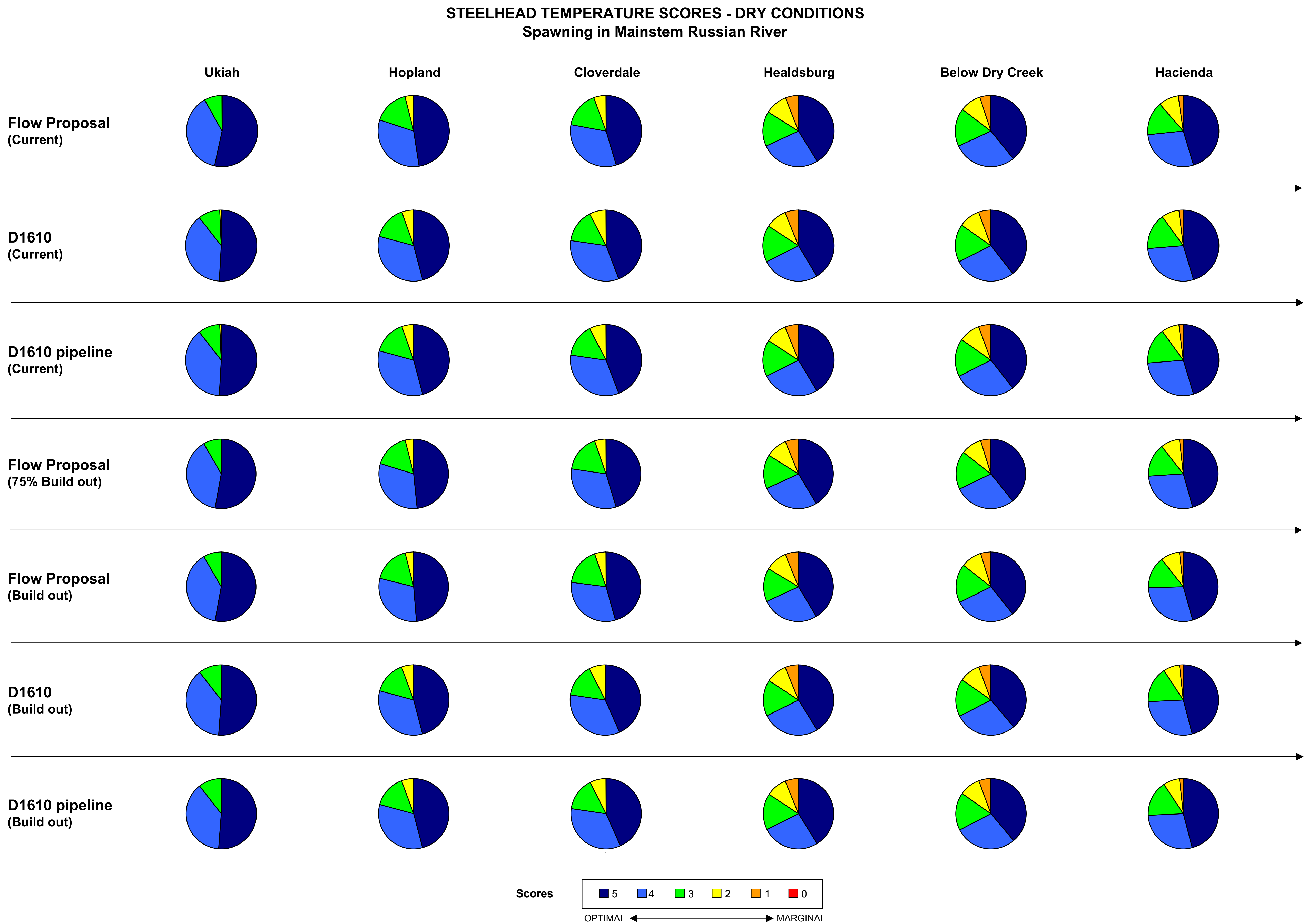

Figure A-67 Steelhead Spawning Temperature Scores for Dry Water Supply Conditions in the Russian River

STEELHEAD TEMPERATURE SCORES - DRY CONDITIONS
Incubation in Mainstem Russian River

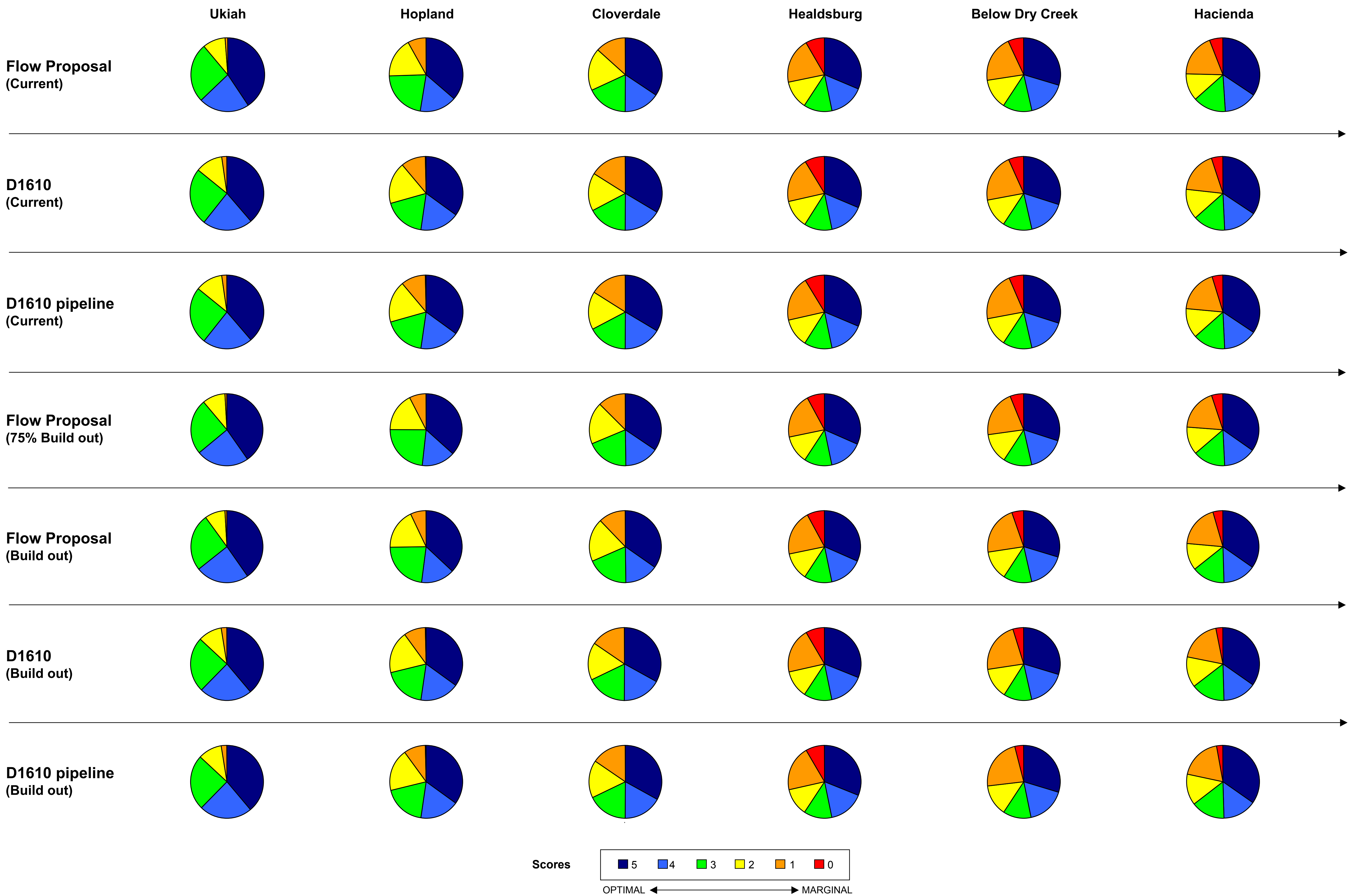

Figure A-68 Steelhead Incubation Temperature Scores for Dry Water Supply Conditions in the Russian River

Figure A-69 Chinook Rearing Flow Scores for All Water Supply Conditions in the Russian River

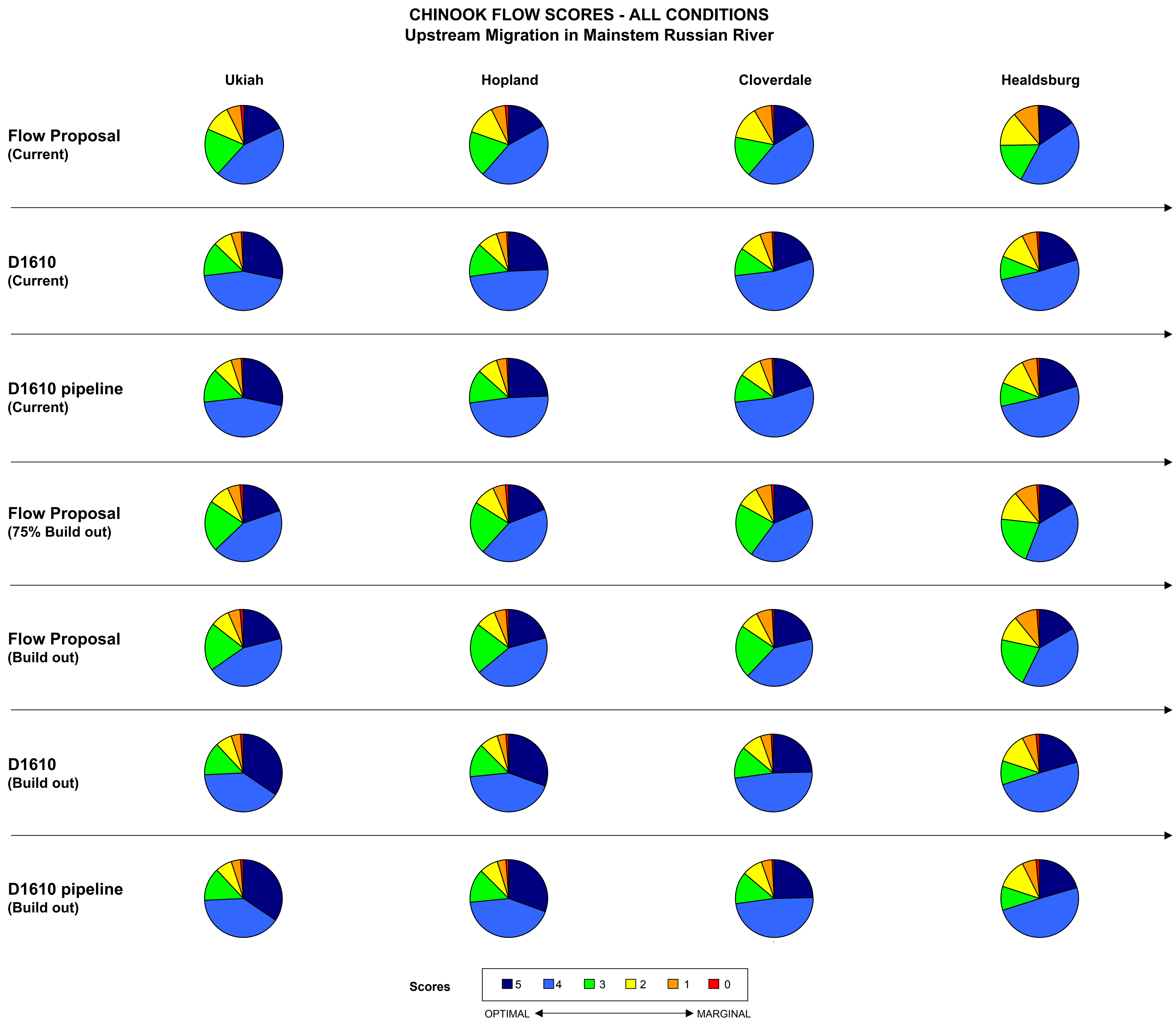

Figure A-70 Chinook Upstream Migration Flow Scores for All Water Supply Conditions in the Russian River

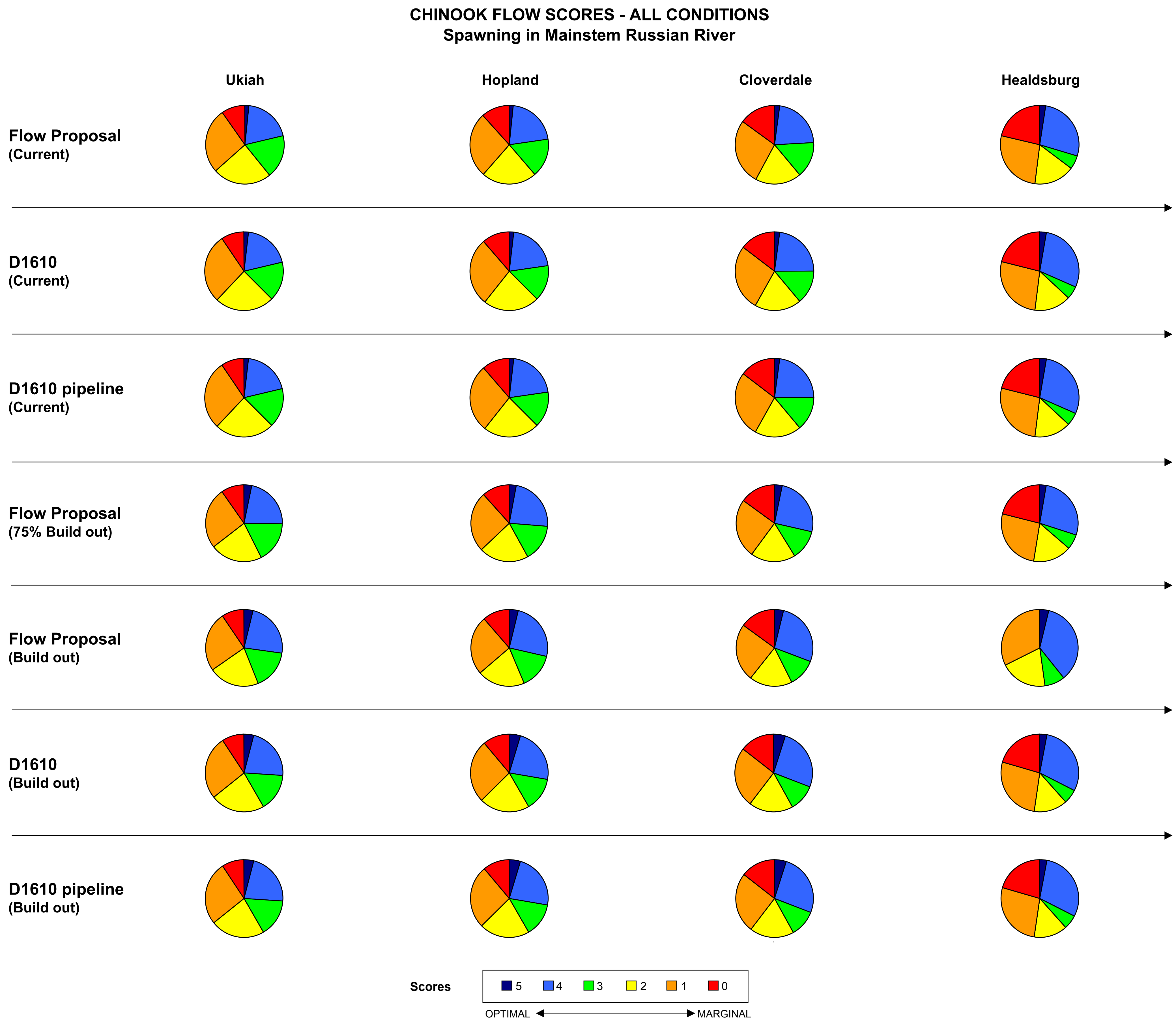

Figure A-71 Chinook Spawning Flow Scores for All Water Supply Conditions in the Russian River

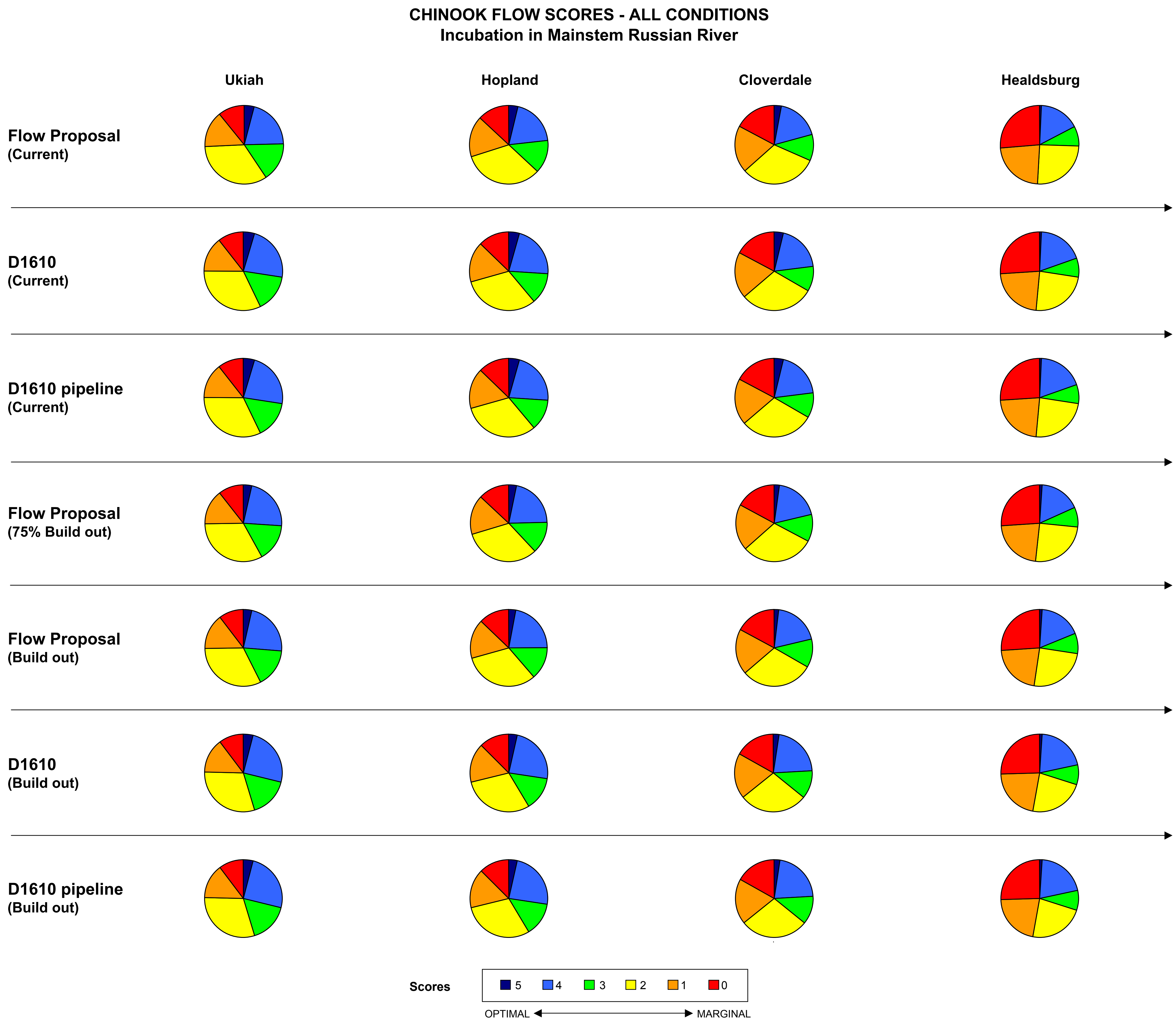

Figure A-72 Chinook Incubation Flow Scores for All Water Supply Conditions in the Russian River

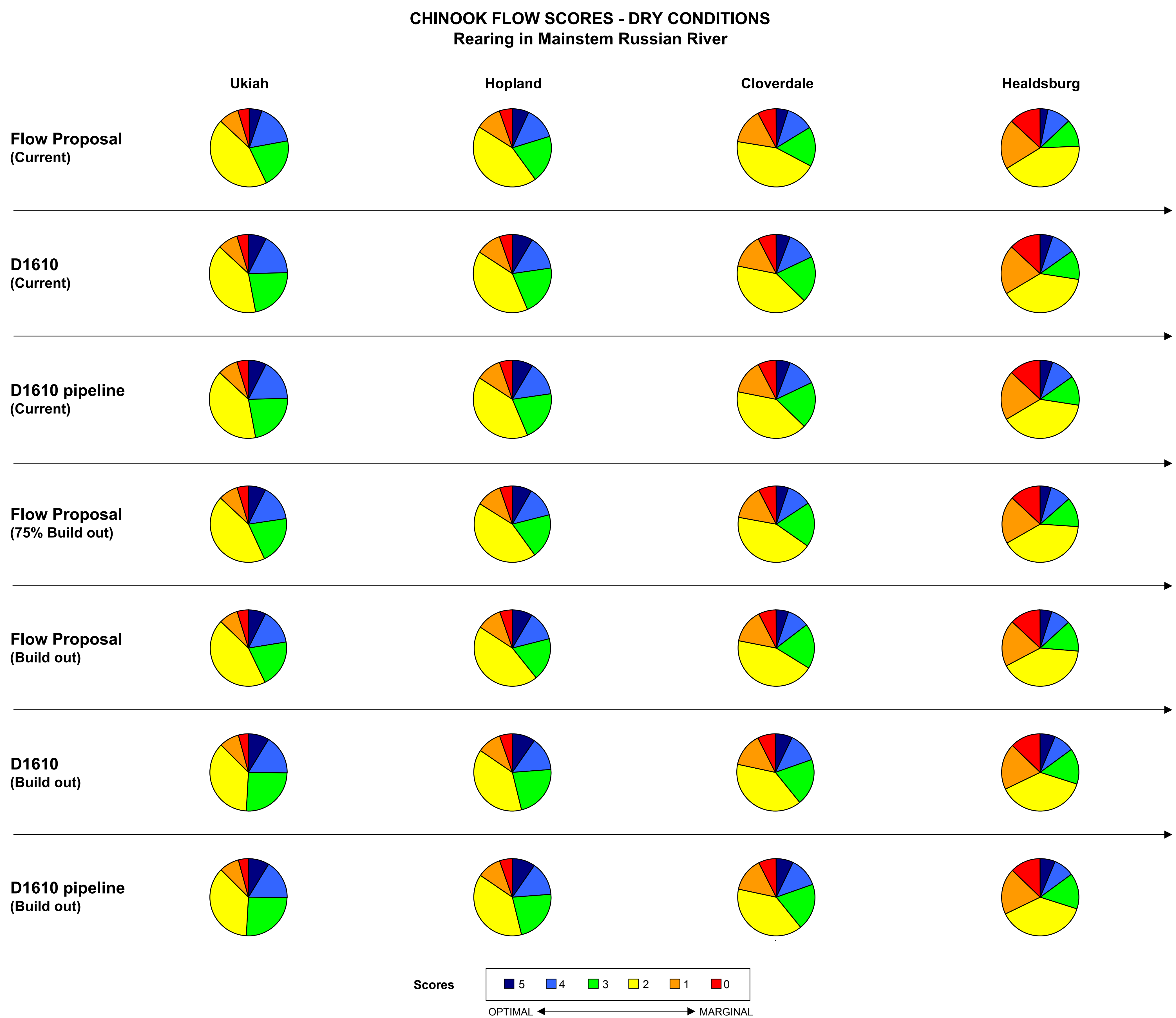

Figure A-73 Chinook Rearing Flow Scores for Dry Water Supply Conditions in the Russian River

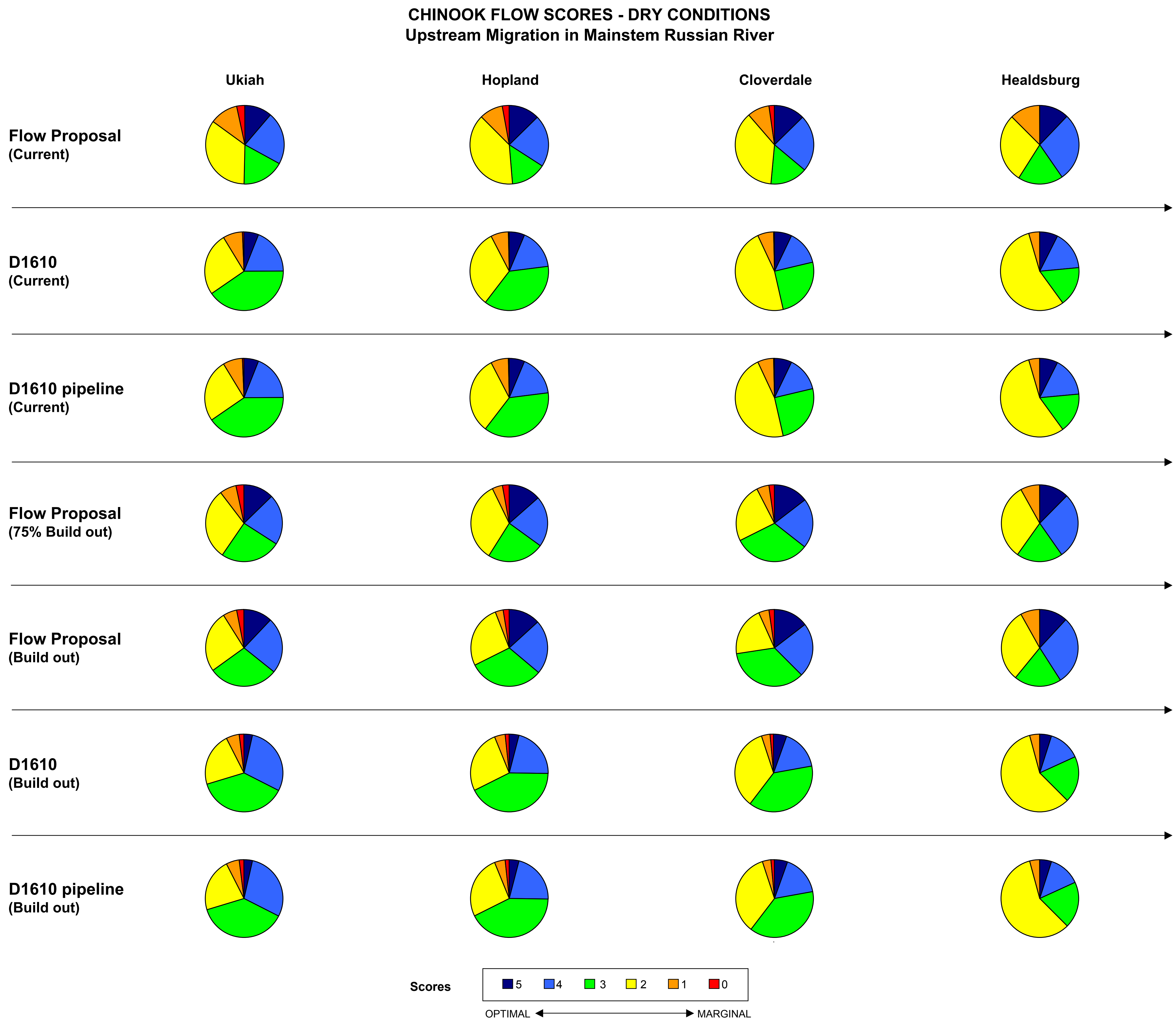

Figure A-74 Chinook Upstream Migration Flow Scores for Dry Water Supply Conditions in the Russian River

Figure A-75 Chinook Spawning Flow Scores for Dry Water Supply Conditions in the Russian River

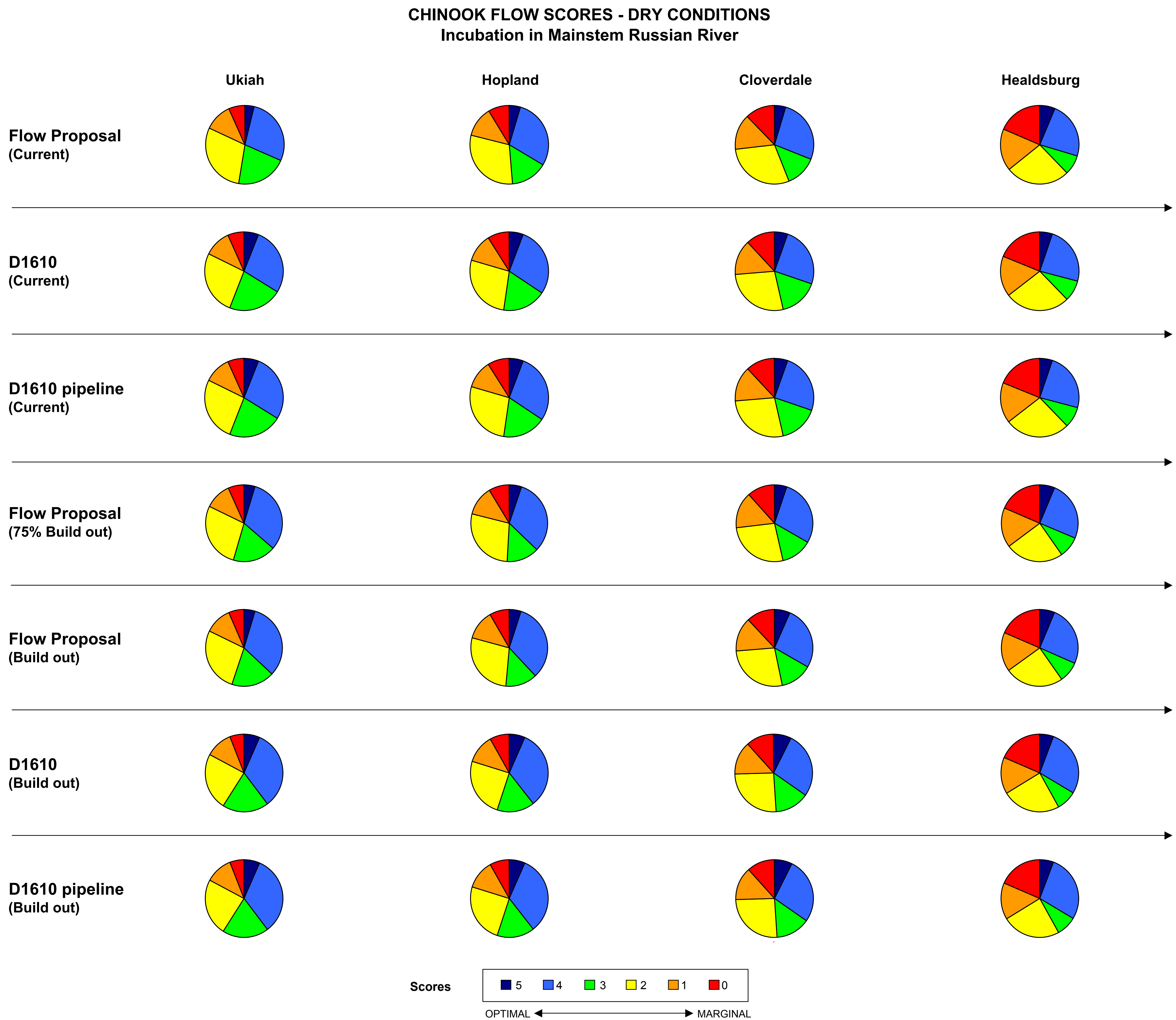

Figure A-76 Chinook Incubation Flow Scores for Dry Water Supply Conditions in the Russian River

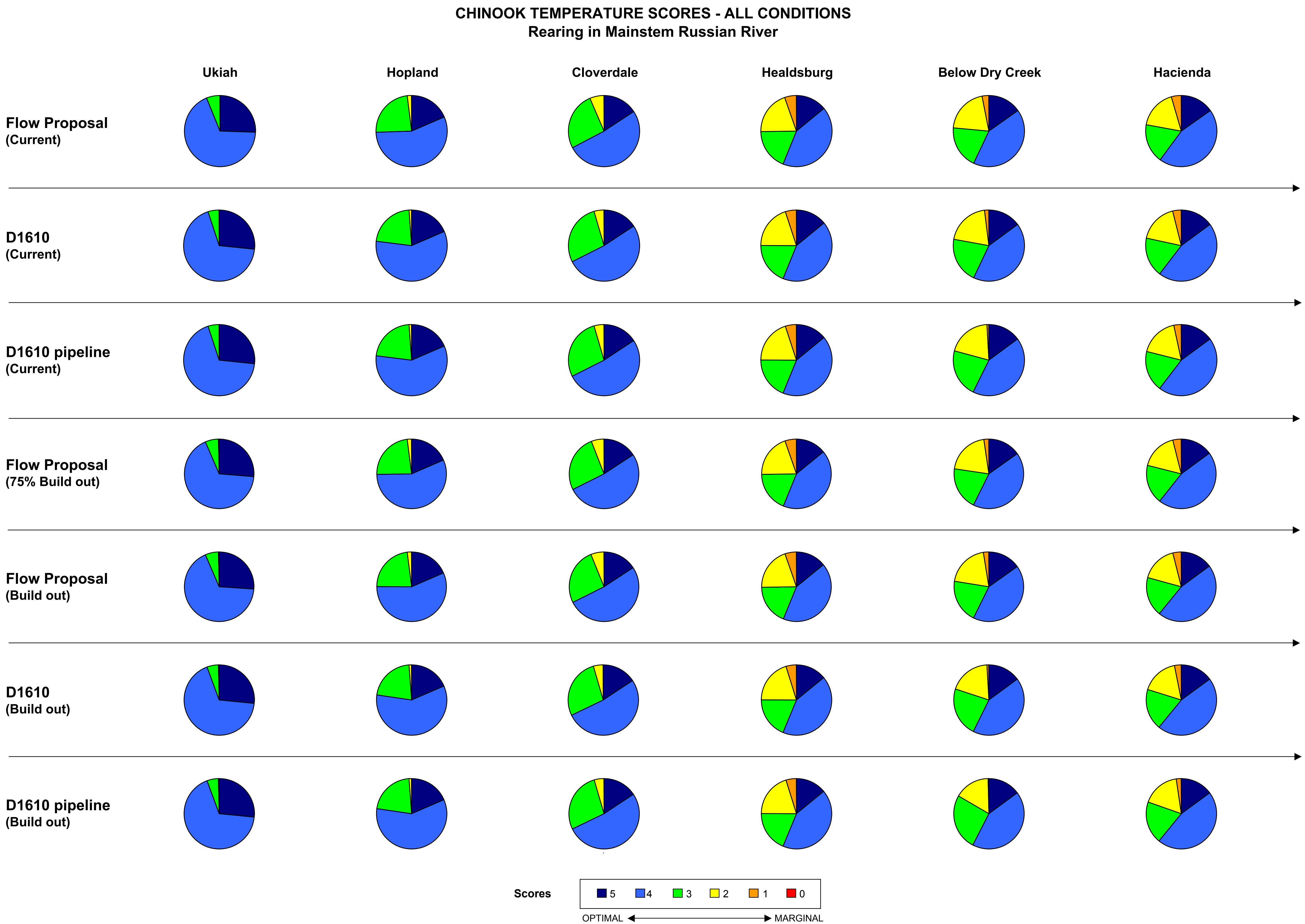

Figure A-77 Chinook Rearing Temperature Scores for All Water Supply Conditions in the Russian River

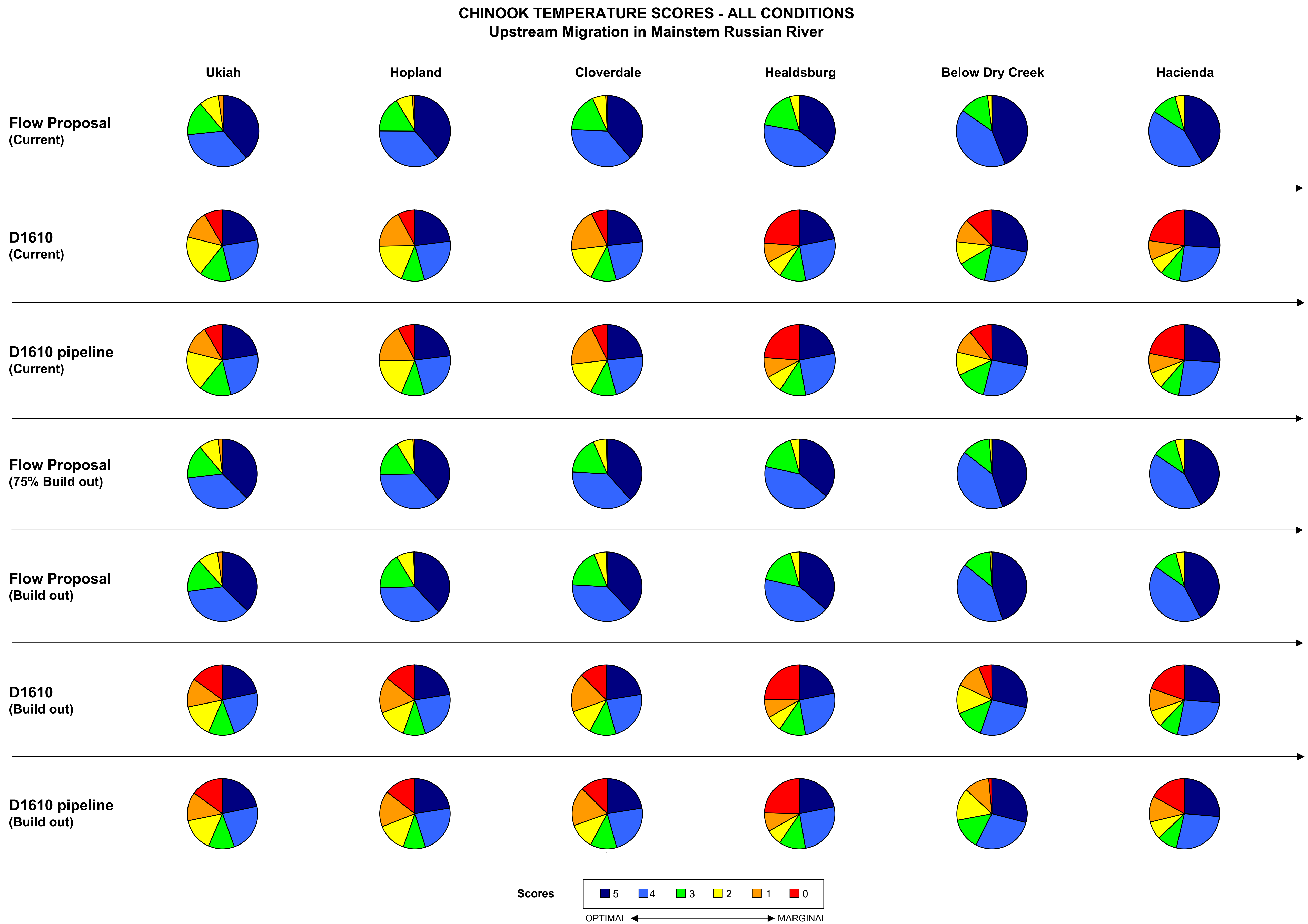

Figure A-78 Chinook Upstream Migration Temperature Scores for All Water Supply Conditions in the Russian River

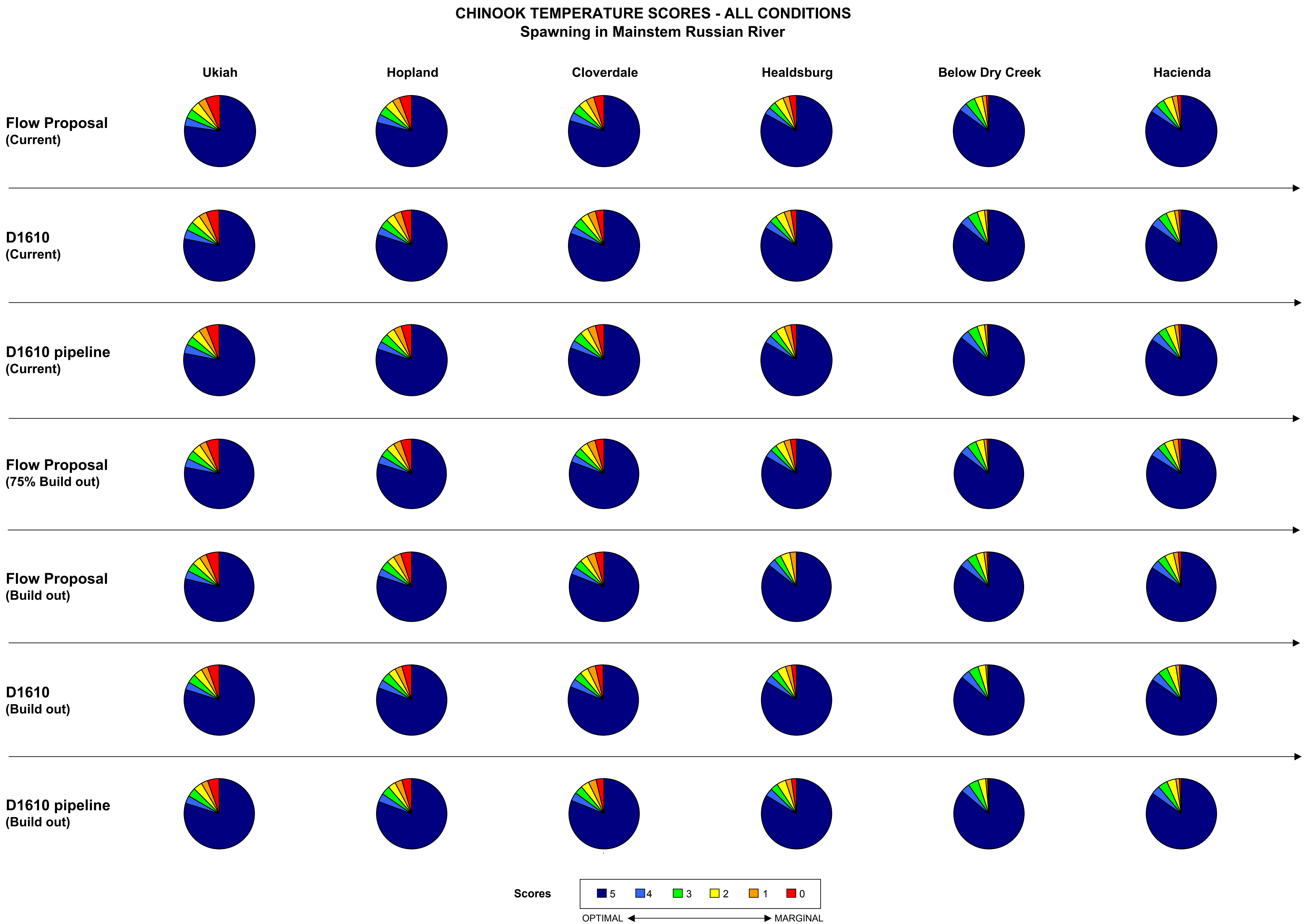

Figure A-79 Chinook Spawning Temperature Scores for All Water Supply Conditions in the Russian River

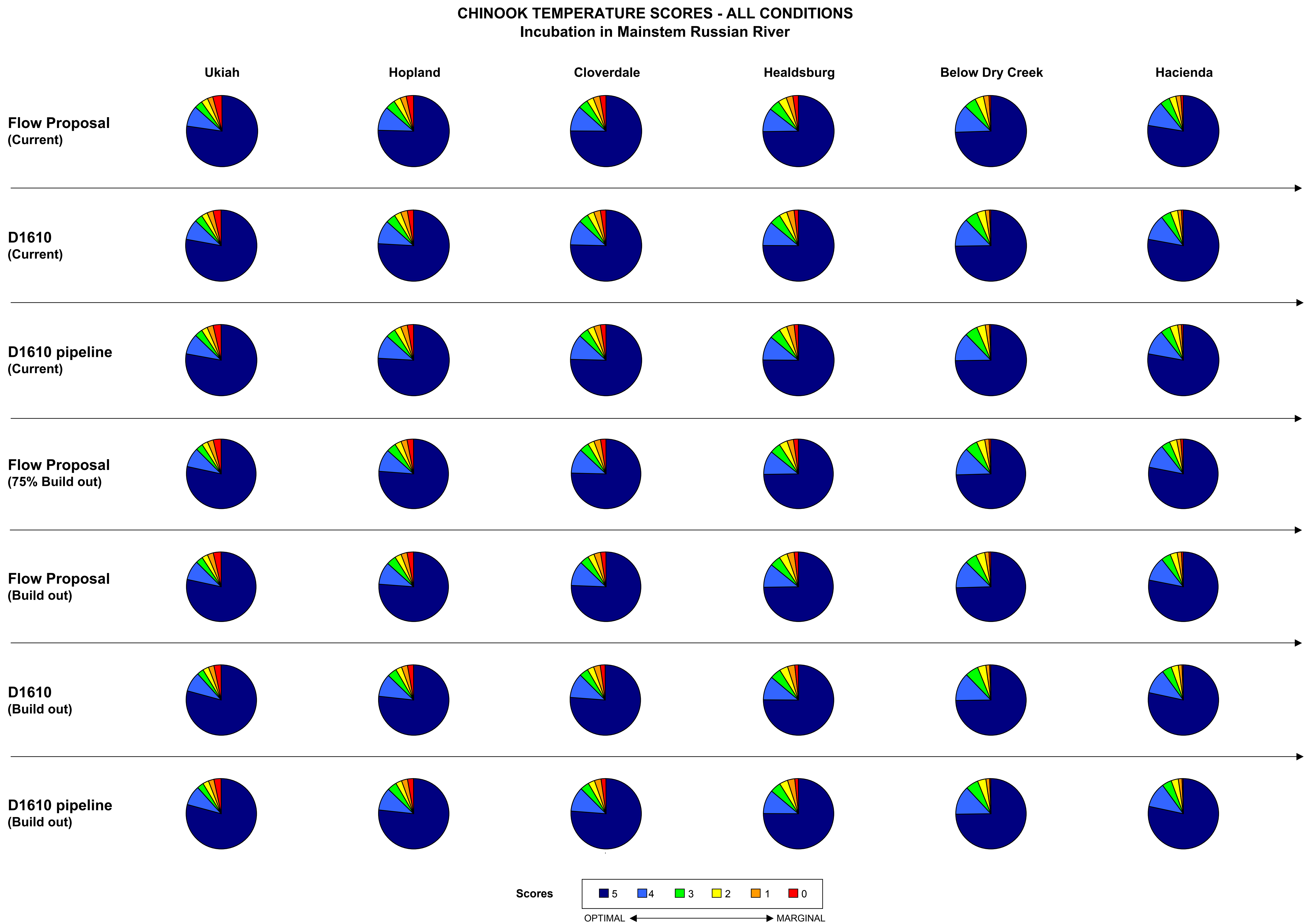

Figure A-80 Chinook Incubation Temperature Scores for All Water Supply Conditions in the Russian River

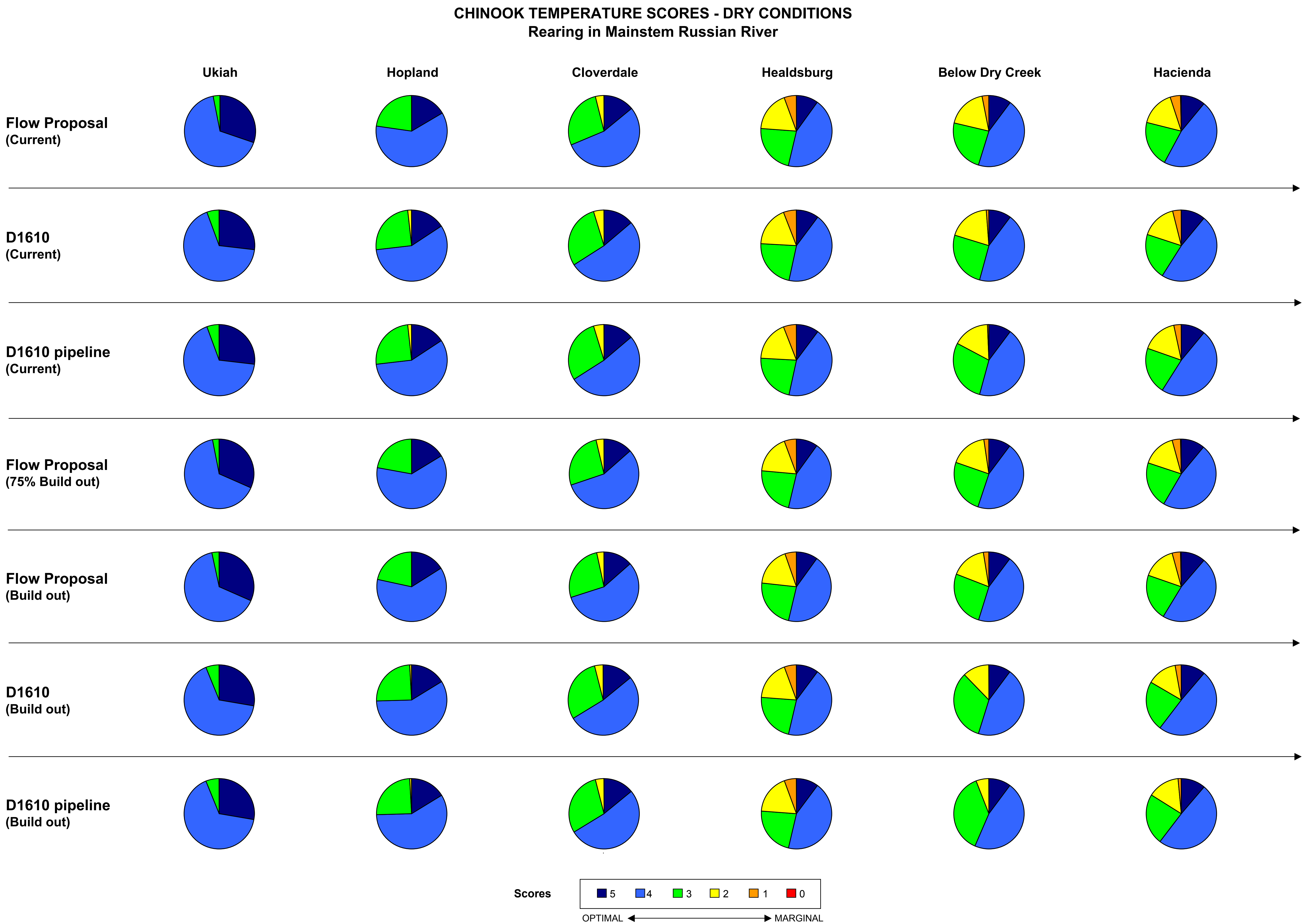

Figure A-81 Chinook Rearing Temperature Scores for Dry Water Supply Conditions in the Russian River

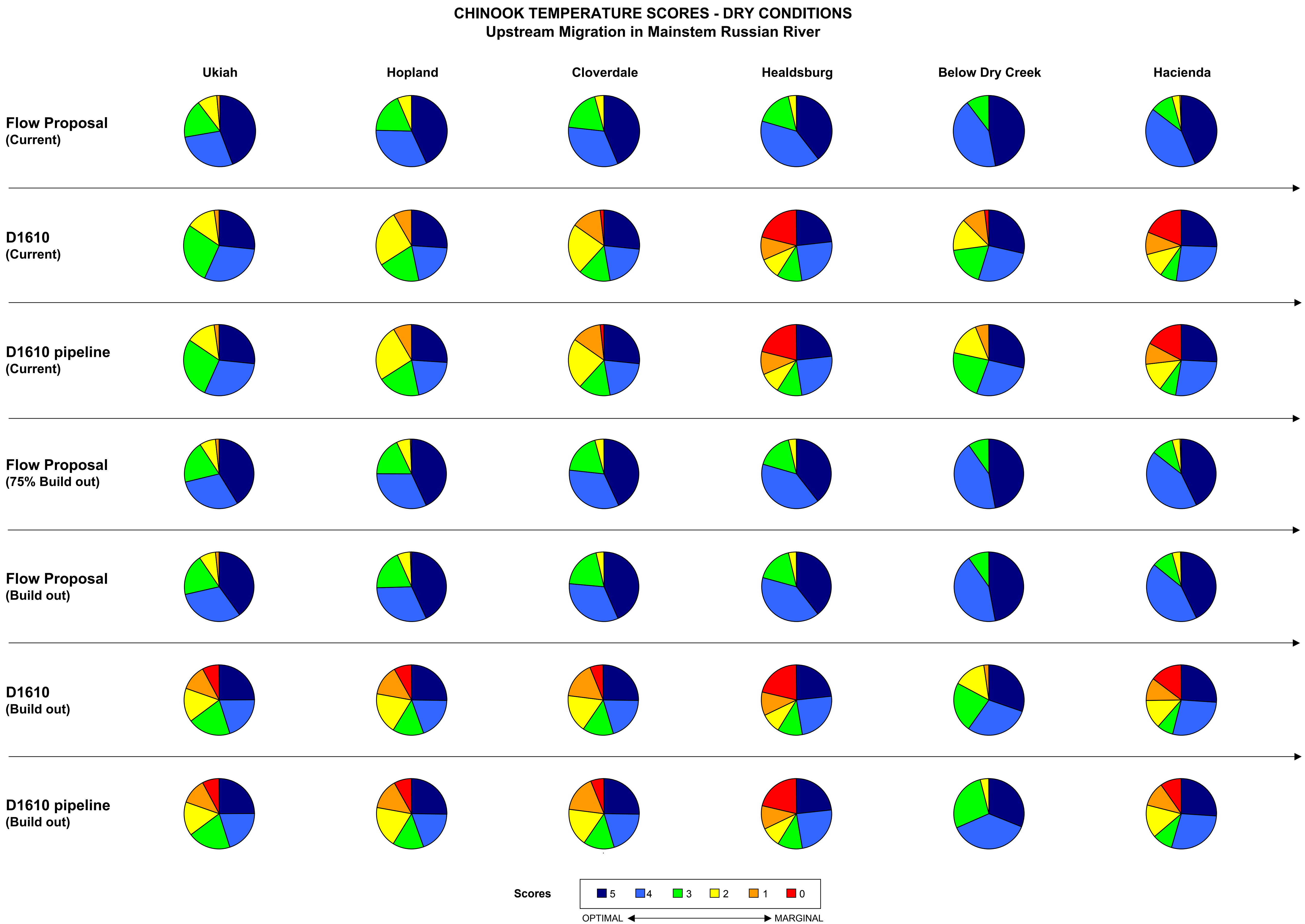

Figure A-82 Chinook Upstream Migration Temperature Scores for Dry Water Supply Conditions in the Russian River

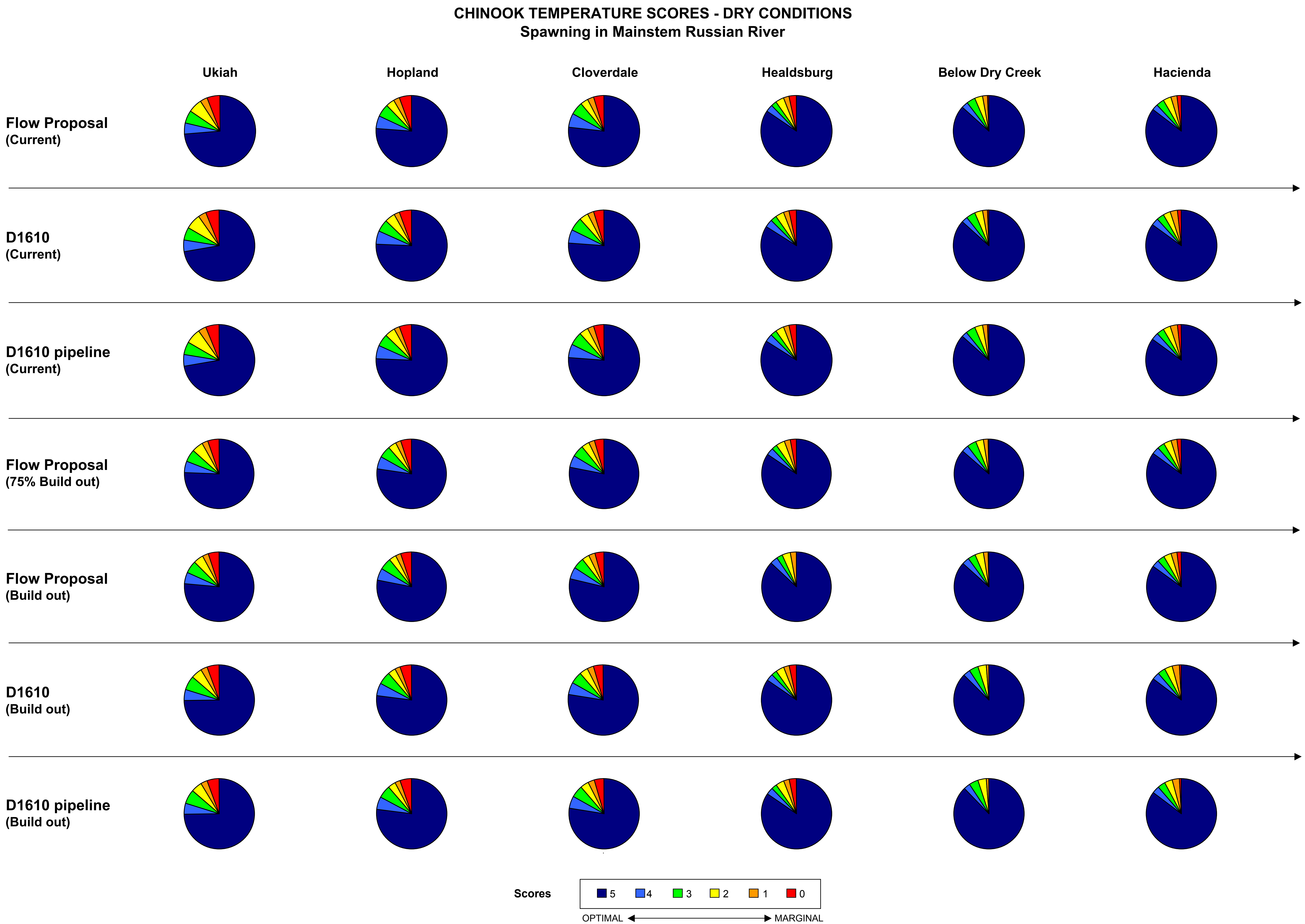

Figure A-83 Chinook Spawning Temperature Scores for Dry Water Supply Conditions in the Russian River

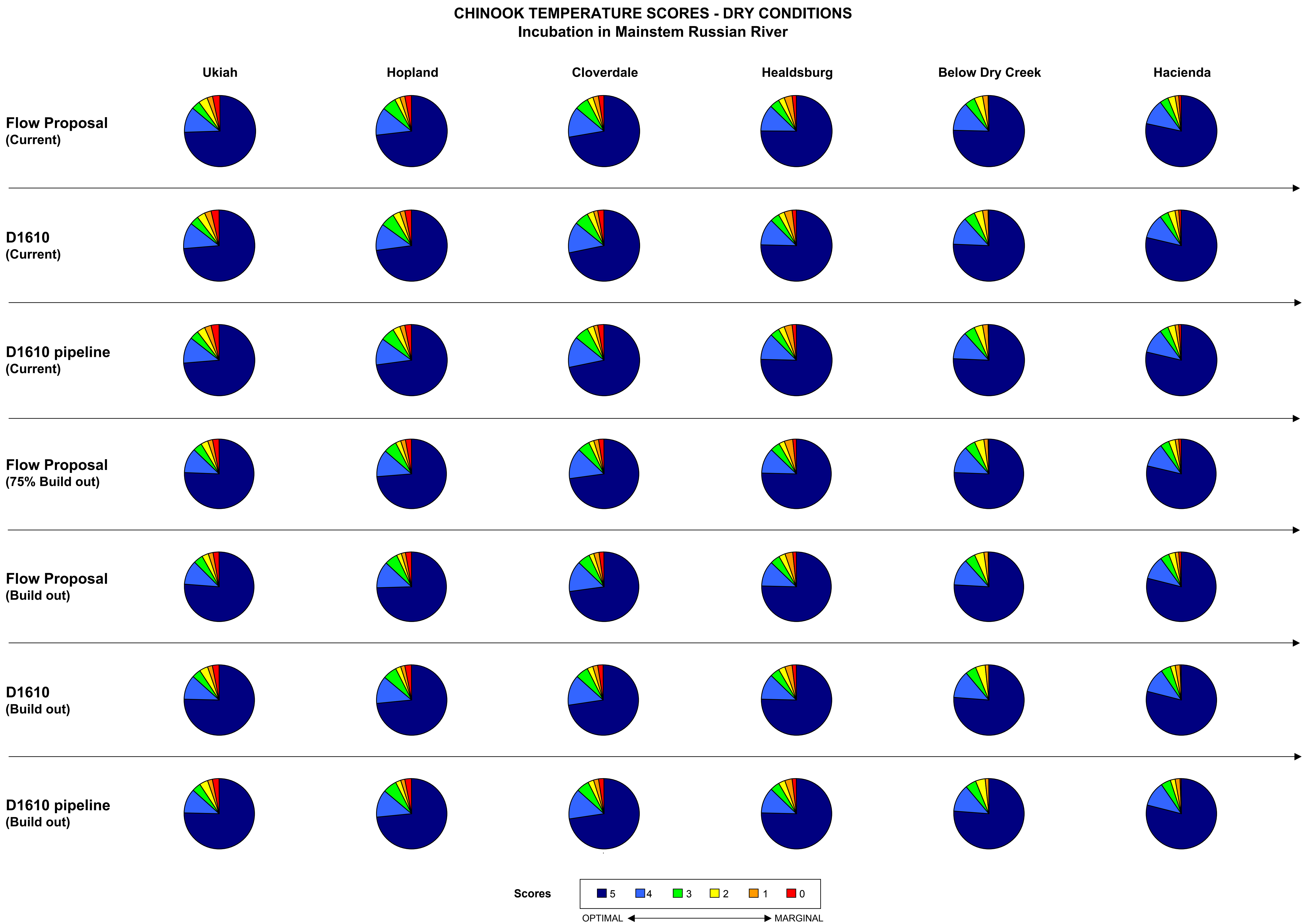

Figure A-84 Chinook Incubation Temperature Scores for Dry Water Supply Conditions in the Russian River

The objective of this action is to maximize water quality for salmonids while conducting artificial breaching to prevent flooding of local property.

A.6.1 ACTION DESCRIPTION

If, in a given year, the Estuary could not be managed as a closed system due to high flows, an Alternate Low-Flow Estuary Management plan would be implemented. This management action may be implemented if changes to D1610 minimum instream flows as requested in the Flow Proposal are not implemented. On the other hand, this action may be implemented after Flow Proposal implementation if, during the 5-year monitoring period, flows are too high to implement the Low-Flow Estuary Management proposal described in Section 4.3 (which would keep the sandbar closed during the summer months and manage the system as a lagoon).

Under baseline conditions, the frequency of sandbar breaching is tied to water levels at the Jenner gage. Under the proposed action, breaching would not be tied to water levels at the Jenner gage, but would be tied to the amount of time the sandbar remains closed. Artificial breaching would be conducted so that the sandbar remains closed no longer than 7 days.

When dry season flows to the Estuary (exclusive of project-controlled flows) are high enough that the water surface elevation at the Jenner gage would exceed 8.0 feet during the dry season and it becomes necessary to breach the sandbar, a program of frequent artificial breaching would be implemented so that the sandbar would remain closed no longer than 7 days. When the sandbar is open, tidal flushing restores water quality. The Estuary would be kept open to tidal mixing throughout the remainder of the dry season with this program of frequent breaching. Breaching would follow the protocols discussed in Section 4.3.3. The sandbar would be breached frequently enough that the water level at the Jenner gage would not exceed 7 feet.

A.6.2 EFFECTS ON PROTECTED SPECIES

As discussed in Section 5.3, infrequent artificial breaching can result in poor water quality conditions and fluctuating conditions that reduce the invertebrate foodbase of rearing fish. Habitat conditions would be better for salmonids if the Estuary is open to tidal mixing or if the lagoon remains closed during the summer and converts to a freshwater system. The Alternate Low-Flow Estuary Management proposal would implement a program of frequent breaching if needed. The potential effects of the proposed action listed below are evaluated in this section.

- Negative or beneficial effects on water quality
- Effects on juvenile rearing habitat

- Opportunity for premature adult upstream migration
- Effects on juvenile downstream migration
- Increased risk of predation
- Increase in incidental angling pressure or poaching

A.6.2.1 WATER QUALITY

When the sandbar closes, water quality begins to degrade over several days or weeks, depending on the level of inflow to the lagoon (MSC 1997a, 1997b, 1998, 2000; SCWA 2001). When the sandbar is breached, the Estuary is opened to tidal mixing and suitable water temperature and DO is restored, first near the river's mouth and eventually in upstream areas. Five years of monitoring data document that poor water quality begins to develop very rapidly after the sandbar closes.

Although water temperature, DO, and salinity would not be as stable as they would be under the Low-Flow Estuary Management proposal outlined in Section 4.3, the duration and severity of poor water-quality events would be controlled by keeping sandbar-closures short. This may result in a slight improvement in habitat conditions over baseline conditions because the duration of sandbar closure events (and short-term, poor water quality conditions) would be shorter. Under this Alternate Low-Flow Estuary Management, the sandbar would be breached frequently enough that it would not remain closed longer than about a week. While poor water quality develops within that time, the length of time it persists would be limited by frequently introducing tidal flushing. For this reason, a score of 4 is assigned (Table A-25). Additionally, tidal flushing would reduce potential negative water-quality effects due to nutrient or pollution loading. The salmonid life-history stages that are most likely to be affected are juvenile rearing, and upstream Chinook salmon migration.

Table A-25 Water-Quality Evaluation Criteria — Alternate Low-Flow Estuary Management

Category Score	Frequency of Artificial Breaching (time sandbar remains closed)	Score*
5	0-5 days	
4	6-10 days	Co, St, Ch
3	11-14 days	
2	15-21 days	
1	> 22 days and < 40 days	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

A.6.2.2 JUVENILE REARING

Because the duration and severity of poor water-quality events would be controlled, negative effects on rearing habitat for steelhead and Chinook salmon, and possibly coho salmon rearing or passage, would be reduced to the fullest extent possible. However, fluctuating salinity levels would likely result in a decrease in the invertebrate food base, and improvements to summer-rearing habitat expected under the Low-Flow Estuary Management action proposed in Section 4.3 would not be realized.

A.6.2.3 Potential to Flush Juvenile Salmonids Prematurely

When the sandbar is breached during the summer, there is a potential for juvenile salmonids to be flushed out of the Estuary before they are ready to leave. However, observations by SCWA staff during breaching events under the current management plan suggest that the risk is low.

When the sandbar is breached, the breach channel is not established instantaneously and more than a day may be required to drain the Estuary (RREITF 1994, MSC 1997a; 1997b; 1998; 2000). Channel development depends on the difference in water level between the Estuary and the ocean, and on the width of the sandbar. During an artificial breach on October 7, 1993, the channel width as it developed was measured. Water level in the Estuary was approximately 8.9 feet (NGVD). The channel enlarged from about 10 feet wide (the width of the bulldozer used for breaching) to 225 feet within 3 hours.

SCWA staff's observations during artificial breaching events suggest that while water velocity within the breach channel is very high, velocity in the Estuary is not (S. White, SCWA, pers. comm. 2000). A hydraulic head between low tide and gage heights up to 7.5 feet creates a rush of water when the berm is first breached. The trench is about 10 feet wide and a couple of feet deep when first dug, but by the time the water has slowed the channel can be 100 feet wide. However, water velocities in the Estuary appear to be nondetectable. Gulls have been observed floating on the water 50 to 100 feet from the breach. Seals sometimes avoid the channel swimming within 20 feet of the wash, but have also been observed to swim through the channel on several events (J. Martini-Lamb, SCWA, pers. comm. 2003). These observations suggest that the risk of juveniles being flushed out during a breaching activity is low.

As stated in Section A.6.1, the sandbar would be breached frequently enough that the water level at the Jenner gage would not exceed 7 feet. Limiting the height of the water in the Estuary before breaching minimizes the risk of flushing flows in Willow Creek, and is likely to have the added benefit of maintaining the low risk of flushing juvenile salmonids during artificial breaching.

A.6.2.4 Adult Upstream Migration

Adult salmonid passage requirements include passage through the sandbar and Estuary from the ocean, and good water quality when passage occurs. Artificial breaching during the summer provides more passage opportunities than would occur under natural conditions. A key consideration is whether water quality is sufficient when additional passage occurs, both in the Estuary and in the mainstem Russian River.

Peak migration for adult coho salmon and steelhead occurs much later in the year than for Chinook salmon. Therefore, effects of artificial breaching would most likely occur with adult Chinook salmon. Although peak spawning for Chinook salmon occurs in October and November, adults begin to congregate at the Russian River's mouth in late August.

When winter rains begin, water quality in the river and Estuary improves, and this is the time that ocean conditions change so that natural breaching of the sandbar is more likely to occur.

Artificial breaching of the sandbar produces freshets that may attract early adult Chinook salmon into the Estuary. If artificial breaching of the sandbar were to give Chinook salmon access to the Estuary or river while water quality was still poor, stress or mortality could occur. Moreover, if they begin an upstream migration, they may experience increased stress or mortality in the mainstem Russian River if they encounter low flows or poor water quality. Reduced summer flow in the lower river may reduce passage conditions. Chinook salmon may experience stranding in low water areas such as riffles or in fish passage facilities.

Preliminary data from the fish ladders at SCWA's inflatable dam at the Mirabel diversion facilities indicate that while Chinook salmon may appear as early as late August, they generally pass this facility later. Although it is possible that a few adult Chinook salmon may begin their upstream migration (under natural or artificial breach events) when water quality in the river is poor, the primary migration period occurs in October and November, often after the rains have begun. Therefore, individual fish may be affected, but the risk to the Chinook salmon population is likely to continue to be low.

A.6.2.5 Juvenile Outmigration

Juvenile salmonid passage requirements include passage through the sandbar and Estuary from the ocean, and good water quality when passage occurs. It is important that suitable water-quality conditions for passage are maintained in the Estuary during passage opportunities. If the sandbar were to close in spring or early summer, artificial breaching would provide more passage opportunities than natural breaching would. As discussed above, by eliminating infrequent artificial breaching and maintaining tidal flushing, the duration and intensity of poor water-quality events can be minimized. Furthermore, higher spring flows during peak downstream migration would help to maintain suitable water quality. Therefore, under the proposed action, artificial breaching is not likely to substantially degrade habitat during smolt migration periods. Frequent breaching also benefits salmonid smolts by limiting the time that fish may be trapped behind the sandbar when they are physiologically ready to emigrate to the ocean.

A.6.2.6 Predation

By concentrating salmonids through a breach opening while pinnipeds are present, artificial breaching could potentially expose them to an increased risk of predation. The most abundant pinniped species are harbor seals and their numbers peak in the late winter and mid-summer (MSC 2000). In 5 years of monitoring, seal numbers fell when the sandbar was closed and rose when it opened, whether the breaching was natural or artificial. A breach opening makes it easier for seals to get to a preferred haulout site inside the sandbar. Numbers at Jenner in 1999 were highest during March through April, and numbers fell dramatically after July. Pinnipeds are present in lower numbers at other times of the year.

While the sandbar may be opened naturally at any time of the year, artificial breaching would most likely occur during the early part of adult Chinook salmon spawning migration, and may occur during the late part of juvenile salmonid migration (although it may occur earlier or later in some years). The sandbar often remains open or breaches naturally during high flows, which corresponds to peak adult salmonid migrations and peak juvenile migration, so artificial breaching is not likely to be required during those times.

Predation risk scores (Table A-26) are applied to structural and access criteria for salmonids. Artificial breaching activities can potentially concentrate juvenile or adult salmonids as well as seals. Therefore, a score of 2 is assigned for the structural criteria.

Artificial breaching of the sandbar does not increase pinniped access to areas that they have not historically been, although it does appear to occasionally increase access to their preferred haulout sites within the Estuary near the river mouth. Pinniped predation is a natural occurrence, and pinniped populations have historically been well-established. Therefore, a score of 3 is assigned for the access criteria.

While creating an artificial breach has the potential to increase pinniped predation, a wide opening with ample flows will minimize the risk. Because pinnipeds have historically used the natural sandbar opening and the mouth of the Russian River for foraging, a new risk to protected species has not been introduced. Therefore, only a low risk to a small portion of migrating salmonid populations is likely to occur.

Table A-26 Predation Criteria Scores for Adult and Juvenile Salmonids

Category Score	Evaluation Criteria	Score*
	Component 1: Structural Criteria	
5	No features that concentrate salmonids or provide cover for predators; concentrations of predators not found.	
4	No features that concentrate salmonids; predator cover near; predators in low abundance locally.	
3	Features that concentrate salmonids; no predator cover near; predators in medium to low abundance locally.	
2	Features that concentrate salmonids; predator cover near; predators in medium- to low-abundance locally.	Co, St, Ch
1	Features that highly concentrate salmonids; predators abundant locally.	

Table A-26 Predation Criteria Scores for Adult and Juvenile Salmonids (Continued)

Category Score	Evaluation Criteria	Score*
	Component 2: Access Criteria	
5	Structure does not allow passage of predators, predators not present near structure.	
4	Structure does not allow passage of predators, predators present near structure.	
3	Structure provides limited passage of predators, or limited passage to areas where they are already well-established; predators not present near structure.	Co, St, Ch
2	Structure provides limited passage of predators to areas they have historically not been found or have been found in limited numbers; predators present in limited numbers near structure.	
1	Structure provides passage of predators to areas they have historically not been found or found in limited numbers; predators present or migrate to structure.	

*Co = coho salmon, St = steelhead, Ch = Chinook salmon

An analysis of harbor seal scat samples in the winter of 1989 and spring of 1990 determined that the harbor seals feed primarily outside the Estuary on slow-moving or schooling prey (RREITF 1994), rather than on salmonids. While harbor seals fed on lamprey migrating through the Estuary, other up-river migrants, including adult salmonids, were not an important part of their diet. Predation on migrating juvenile salmonids increased significantly under only one unusual circumstance, coinciding with a large hatchery release, rain, and a closed Estuary that trapped the smolts.

A.6.2.7 Increase in Incidental Angling Pressure or Poaching

Chinook salmon spawners begin to concentrate at the mouth of the Russian River around mid-August, but peak migrations usually occur after October or November. In some years, the sandbar opens naturally in the early fall, and adult Chinook salmon may enter the river early. An artificial breach would create an additional passage opportunity, and flows from the river may attract Chinook salmon into the Estuary while water quality is poor or river flow is still low.

If adult Chinook salmon were concentrated into areas that made them more vulnerable to incidental angling or poaching, the risk would be increased. For example, if they were caught on a riffle during low flows, or could not surmount fish ladders because of low flows, they could be at an increased risk. Potential problem areas include riffles on the lower river below Guerneville, and also below some of the fish ladders where fish congregate before moving upstream (R. Coey, CDFG, pers. comm. 2000). However, these ladders have recently been improved, and may be less of an issue that they were previously. Under the Flow Proposal, flow in the lower river may be reduced in the early fall, which would exacerbate the situation. Some Chinook salmon enter the larger tributaries in early pulse rains, and then become stranded when the rains stop and adequate flows have not begun. This was verified on Feliz and Forsythe creeks in 1999 (R. Coey, CDFG, pers. comm. 2000).

The Russian River is open to fishing in the fall. Although fishing is not permitted for Chinook salmon, when Chinook salmon congregate outside of the Russian River they may be subjected to incidental hooking or mortality. Access to the river in itself is not likely to increase exposure to anglers. However, if some early Chinook salmon become stranded during low-flow or poor water quality conditions, they could be subjected to increased fishing pressure.

In the early fall, artificial breaching may provide additional passage opportunities for early Chinook salmon adults, and if any of these fish migrate into the mainstem when water quality is poor, they may be subject to increased predation or poaching. However, video monitoring at the SCWA inflatable dam indicates that most Chinook salmon migrate in October and November, about the time that the rainy season begins. Therefore, although a few fish may occasionally be affected (both under natural or artificial breaches), the risk to the population is likely low.

A.6.2.8 SUMMARY OF EFFECTS AND BENEFITS

This action would be implemented if, for a given year, the Estuary could not be managed as a closed system due to high flows (excluding project-controlled flows). By limiting the amount of time the sandbar remains closed, the duration and severity of poor water-quality events would be controlled.

Fluctuating water quality conditions (temperature, DO, and salinity) would result in reduced habitat conditions compared to the Low-Flow Estuary Management proposal. Under the baseline management plan, there is a low risk of prematurely flushing juveniles out of the Estuary (particularly steelhead), of creating passage opportunities for early Chinook spawners when river conditions are unsuitable, creating potential opportunities for pinniped predation, and increasing incidental angling pressure or poaching opportunities on early Chinook adults. By continuing summertime artificial breaching at current levels, the low-risk level for these effects would be maintained, resulting in effects to some individual fish. However, the cumulative effects to populations of listed fish species would be low.

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The objective of this action is to construct off-stream or on-stream detention basins in constructed flood control channels at sites where they might be appropriate. This action could potentially help maintain flood control channel capacity and reduce the need for sediment or vegetation maintenance activities downstream.

A.7.1 ACTION DESCRIPTION

SCWA could construct off-stream or on-stream detention basins in areas where they may be feasible and appropriate. Detention basins would be located, to the extent possible, in upper reaches of the tributaries where fewer fish are present. An on-stream basin would provide both sediment and flow detention, while an off-stream basin would provide only flow detention. A detention basin would be designed to help maintain flood control channel capacity and reduce the need for sediment or vegetation maintenance activities, thereby reducing potential effects to salmonid habitat. On-stream or off-stream detention basins would be sited on constructed channels, or in sites such as urban parks and parking lots (that could be periodically inundated during the rainy season), near stream locations where frequent channel maintenance has the potential to alter habitat for protected fish species.

Urbanization increases stormwater runoff volumes and peak flow rates, while often decreasing the area of historical flood plains. Detention facilities temporarily store stormwater runoff and limit peak runoff rates. Ponds, parking lots, and parks are examples of common off-stream detention facilities that temporarily store storm runoff and are emptied after a storm ends. As an example, Cook Creek has an on-stream detention structure that is designed to capture a portion of the sediment load, thereby decreasing sedimentation of downstream areas.

Detention basins are often required for new developments. However, numerous small detention facilities within a watershed may cumulatively have uncertain hydrologic effects because the timing of flow detention and release is not coordinated, and result in possible exacerbation of flooding downstream. There may be an advantage to having larger, regional detention basins that are designed, operated, and maintained by a public agency. This could reduce existing channel maintenance needs downstream.

Some of the constructed flood control channels of the Mark West Creek watershed, especially those in the Rohnert Park area that carry substantial sediment loads from Sonoma Mountain, require more extensive sediment removal and vegetation management to maintain flood control capacity. In areas that require frequent or extensive channel maintenance, off-stream or on-stream detention basins may be appropriate. An off-stream detention basin could be designed to capture a portion of flood flows and release them over a longer period of time, thereby decreasing the magnitude of downstream flood flows. An on-stream detention basin may be appropriate in a channel with large sediment loads to concentrate sediment deposition in an area where minimal disturbance would be required to remove it. This would decrease the need to perform extensive sediment maintenance over longer lengths of channel.

Design criteria would be specific to a particular location and need. In general, a detention basin would be designed to capture the storage volume needed to control runoff for a specified set of design storms and release it at a rate that would reduce flood risk downstream. It would operate passively. The outflow structure would be at a lower elevation than the inflow structure. Inflow and outlet structures would be designed to account for erosion, deposition, and maintenance due to clogging. Because the primary function for these basins would be for flood control or sediment deposition rather than for water quality control, outflow rates would be high and water residence time would be low.

Both on- and off-stream detention basins would be sited in areas where frequent channel maintenance has the potential to alter habitat for protected fish species, either locally or downstream. Where possible, detention basins would be sited where they would have the least effect on salmonid rearing or migration, such as in upper reaches of the channels. They would also be sited in areas where they would have significant flood control benefits. An on-stream basin would typically be located on a section of stream that widens, thereby taking advantage of the opportunity to decrease flow velocities and increase sediment deposition. Site selection and detention basin design would be conducted with participation of a qualified fish biologist.

A.7.2 EFFECTS ON PROTECTED SPECIES

Off-stream detention basins have the potential to entrap salmonids, and on-stream detention basins have the potential to affect salmonid migration. By capturing streamflow in detention storage until they fill and spill, on-stream detention basins can alter the magnitude and timing of downstream flow. Altered sediment transport can affect downstream habitat.

Because an off-stream detention basin would be small, the proportional volume of stormwater runoff actually stored would be small. Furthermore, residence time of water detained in the basin would be short, typically less than a day or two. Therefore, the period of time that fish would be entrained would be short. Because only a portion of the storm flow would pass though an off-stream detention basin, a score of 4 was given to this action relative to the potential for entrapment (Table A-27). On-stream detention basins would not divert any flow and would therefore score a 5.

The basin could be graded to minimize fish stranding as flood waters recede, and to direct fish toward the outlet structure. This design would also minimize the risk of predation on fish entrained in the basin. Therefore, with a proper design, the risks associated with entrapment may be low. Both off-stream and on-stream basins would score a 4 relative to their potential effects on fish stranding (Table A-28).

Table A-27 Passage Evaluation Criteria for Juvenile Salmonids – Opportunity for Entrapment, Impingement, or Injury during Operation – Amount of Water Diverted

Category Score	Evaluation Category	Score
5	Facility does not affect any surface-water flow.	On-stream
4	Facility diverts less than 25% of surface-water flow.	Off-stream
3	Facility diverts between 25-50% of surface-water flow.	
2	Facility diverts between 50-75% of surface-water flow.	
1	Facility diverts more than 75% of surface-water flow.	

Table A-28 Habitat/Flow Recession Interaction Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category	Score
5	Habitat features unlikely to induce stranding.	
4	Few habitat features present to induce stranding.	Off-stream, On-stream
3	Some habitat features that induce stranding, but area affected is small (<30%).	
2	Many habitat features that induce stranding, but area affected is small (<30%).	
1	Some habitat features that induce stranding, area affected is large (>30%).	
0	Many habitat features that induce stranding, area affected is large (>30%).	

Table A-29 Passage Evaluation Criteria for Juvenile Salmonids – Opportunity for Entrapment, Impingement, or Injury – Time Water is Diverted

Category Score	Evaluation Category	Score
5	Facility does not affect surface-water flow during any time of migration period.	
4	Facility diverts surface-water flow during less than 10% of migration period.	Off-stream
3	Facility operates between 10 and 15% of migration period.	
2	Facility operates between 15 and 25% of migration period.	
1	Facility operates during more than 25% of the migration period.	On-stream

On-stream detention basins have the potential to create hard structures that delay or prevent migrating salmonids from passing. By altering flow patterns, new areas of deposition and scour could be created that make fish passage difficult at certain flows. Therefore, fish passage design considerations would be implemented to decrease potential effects to fish passage. Because on-stream basins would be present permanently, they receive a score of 1 for their potential to obstruct passage (Table A-29). Off-stream basins would only function for a short period during storm events; therefore, they are given a score of 4.

Changes to downstream habitat may occur because a detention basin is designed to decrease the magnitude, and alter the timing of, downstream flow. However, these basins are generally designed to compensate for altered flow patterns due to increasing urbanization. Although they do not compensate for increased runoff due to an increase in impervious surface area, they can help restore a reduced runoff rate in an urbanized stream channel. This reduced rate is determined by the design of the facility. Depending on site-specific conditions, downstream salmonid habitat could potentially be improved if flows were to approximate a more natural hydrograph. This effect would likely be attenuated in a downstream direction with inflow from downstream sources.

An on-stream detention basin would concentrate a portion of the sediment and associated pollutant load into one easily-accessible area. This could potentially reduce the need for frequent or extensive channel maintenance in downstream reaches. Detention basins may also assist in the attainment of Total Maximum Daily Loads (TMDLs) for sediment and would reduce pollutant loads from runoff from agricultural or urban areas. If sediment removal is performed less frequently, or if less extensive vegetation removal is required to maintain sufficient flood control capacity, fish passage and rearing or spawning habitat could be improved downstream.

An on-stream detention basin would likely alter salmonid habitat within the footprint of the facility. Because an area of sediment deposition would be created, frequent sediment removal is likely to be required. However, disturbance within one short segment of stream channel, especially one that may have minimal habitat value for salmonids due to heavy sediment loads within the stream, may be offset by the need for less channel maintenance or less aggressive vegetation maintenance in downstream reaches. Potential negative or beneficial effects are likely to be site-specific. Care would have to be taken in the design and maintenance of the basin to maintain fish passage during migration seasons.

A properly designed detention basin could help maintain flood capacity within the constructed flood control channel, have minimal direct effects on salmonids, and, depending on site-specific features, may have benefits for salmonid habitat in downstream reaches.

The objective of this action is to reduce the cumulative amount of gravel-bar grading and extraction that is conducted in the Russian River mainstem.

A.8.1 ACTION DESCRIPTION

The Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) and SCWA were designated as the local agencies responsible for channel maintenance below Coyote Valley Dam. Gravel-bar grading activities and protocols related to streambank erosion control were outlined in Section 4.

SCWA and MCRRFCD would investigate the option of "exchanging" gravel-bar grading locations with gravel mining operations such as Syar Industries or Shamrock Materials, Inc. Under such an exchange, a company with an existing permit to remove gravel from designated gravel bars would exchange one or more of their permitted locations for a gravel bar(s) that SCWA or MCRRFCD have identified for maintenance. Any gravel bars that require work for channel maintenance that are also located in designated aggregate resource mining company reaches would be eligible for an exchange. Work performed would be consistent with protocols and permits established by the aggregate mining company.

A.8.2 EFFECTS ON PROTECTED SPECIES

If exchanges are implemented, they would have the effect of reducing the total amount of gravel removed, or repositioned, within the Russian River. Extraction by gravel miners would remain the same, but the locations would change. Because SCWA and MCRRFCD would be reducing their grading activities, the total activity would be less. This action will also reduce the magnitude of gravel extraction activities in localized areas, and would spread those activities over a greater area.

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APPENDIX B

PROPOSED FLOW REGIME FOR THE RUSSIAN RIVER IMPLEMENTATION PLAN AND PROPOSED PERMIT TERMS

Page

Page

Term	*Definition*
AF	acre-feet
BA	Biological Assessment
cfs	cubic-feet per second
Estuary	Russian River Estuary
MGD	million gallons per day
OEI	optimal Estuary inflow
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers
USGS	U.S. Geological Survey

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B.1.0 Introduction

This plan describes in detail the operational criteria that the Sonoma County Water Agency (SCWA) intends to follow to: 1) comply with the minimum stream flow requirements expected to be prescribed by the State Water Resources Control Board (SWRCB) via amendment of the terms of the SCWA's appropriative water rights permits, and 2) achieve the additional anadromous fishery enhancement objectives of the SCWA's proposed flow regime. This plan describes the criteria for the proposed water rights terms, including the specific minimum flow requirements. Actual flow rates under typical operation of the system are usually higher than the minimum flow rates required by the permit terms. For a more detailed discussion of the flow rates predicted to occur under the Flow Proposal, please refer to sections 4.3 and 5.3.

B.2.0 Minimum Lake Mendocino Releases

The minimum stream flow requirements for the Russian River from Coyote Valley Dam to its Dry Creek confluence are listed in Table B-1:

Table B-1 Minimum Stream Flow Requirements for the Upper and Middle Russian River in cfs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal	150	150	150	100	100	50	50	50	50	50	150/ 75[1]	150/ 75[1]
Dry	75	75	75	75	75	50	50	50	50	50	75	75
Critical	25	25	25	25	25	25	25	25	25	25	25	25
Dry Spring	150	150	150	100	100	50	50	50	50	50	75	75
East Fork	25	25	25	25	25	25	25	25	25	25	25	25

[1] 75 cfs when storage in Lake Mendocino is less that 30,000 AF

The flows labeled as "East Fork" are the minimum flows that apply to the East Fork Russian River between Coyote Dam and its confluence of the West Fork Russian River (the Forks). All the other minimum flows apply to the Russian River from the Forks to its confluence with Dry Creek. Normal minimum flow requirements apply when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year is greater than 130,000 acre-feet or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less. Under these requirements, anytime between November 1 through December 31 storage in Lake Mendocino is less than 30,000 acre-feet, the required minimum flow rate is reduced from 150 cfs to 75 cfs. Dry Spring applies during normal water supply conditions and when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year is less than 130,000 acre-feet or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less.

During those periods when the U.S. Army Corps of Engineers (USACE) is not making releases for flood control purposes, SCWA determines releases from Lake Mendocino. Releases are made during these times, typically during the summer and fall, to maintain the minimum flows listed in Table B-1. Additional releases are made from Lake

Mendocino in accordance with the criteria described in the following sections to satisfy the water supply needs of SCWA and achieve the anadromous fishery objectives of the proposed flow regime.

B.3.0 Lake Mendocino Operating Criteria

Under the water rights permit terms prescribed by Decision 1610 of the SWRCB, SCWA's operating criteria contained no decision logic to base releases from Lake Mendocino on flow conditions in the lower Russian River. However, the proposed flow regime requires just this type of operation. Thus, under the proposed flow regime, the operator must consider not only flow conditions in the upper and middle Russian River (typically controlled at Healdsburg) in deciding the necessary release rate from Lake Mendocino, but also consider information to help the operator anticipate what the conditions in the lower Russian River will be and make releases from Lake Mendocino accordingly.

To do this, the operator considers the "target flows" for the mouth of Dry Creek, Santa Rosa hydrologic subunit monthly demands (which are largely SCWA's transmission system demands), the Santa Rosa subunit tributary inflows, the lower Russian River natural flows (as defined in the proposed water rights permit terms), and lower Russian River transition flows (as defined in the proposed flow regime). This information allows the operator to estimate the flow rates that need to be maintained at Healdsburg in order to attain a specific target flow range in Dry Creek while meeting the water supply demands and the minimum stream flow rates required at the Hacienda Bridge. The target flow rates for Dry Creek are listed in Table B-2.

Table B-2 Target Flow Rates for the Mouth of Dry Creek in cfs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal	75	75	75	70	70	70	70	70	70	50	105	105
Dry	75	75	75	70	70	70	70	70	70	70	75	75
Critical	200	200	200	200	200	200	200	200	200	200	200	200
Dry Spring	75	75	75	70	70	70	70	70	70	70	105	105

The operator accomplishes this by first calculating the appropriate minimum flow for the lower Russian River by considering which of the following three conditions will likely prevail:

1. the sand bar is closed and the optimal estuary inflow is the minimum flow (90 cfs $<Q_{Hacienda}<$ 150 cfs and the month is from April through October);
2. the sandbar is closed and the natural flow is the minimum flow down to the absolute minimum flow rate of 35 cfs (35 cfs $<Q_{Hacienda}<$ 90 cfs) or;
3. the sandbar is open and the transition flow is the minimum flow ($Q_{Hacienda}>$ 150 cfs).

At the U.S. Geological Survey (USGS) stream flow gauging station Russian River near Guerneville, California the specified minimum flow rate refers to a five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum flow requirement).

The parenthetical comments above are assumptions made here for illustrative purposes. In this example (and in SCWA's computer modeling of the impacts of the proposed flow regime) it is assumed that the closure of the estuary will take place whenever the flow at Hacienda Bridge reaches 150 cfs. It is also assumed that the value of the optimal estuary inflow to balance the estuary elevation at 7.0 feet is 90 cfs. However, the operator will, in practice, consider the actual physical conditions in the estuary.

Once the lower Russian River minimum flow has been established, the operator will calculate the expected net SCWA demand at Wohler/Mirabel by subtracting the current tributary inflows from the current demands for the Santa Rosa subunit. Knowing the target flow for Dry Creek, the net demand at Wohler/Mirabel, the minimum flow at Hacienda Bridge, and the minimum flow at Healdsburg, the operator will calculate a target flow at Healdsburg (which may be greater or less than the minimum flow for Healdsburg). The operator then sets the release from Lake Mendocino high enough to either maintain the required minimum flows in the upper and middle Russian River (with an operating margin sufficient to allow for variables beyond the control of SCWA), or so that the anticipated demands between Coyote Valley Dam and Healdsburg will whittle the flow down to the target flow at Healdsburg, or the minimum flow, whichever is greater.

The operator does not know what the exact future demands and tributary inflows will be. Therefore the operator assumes the current demands and inflows will approximate the demands and inflows for three days into the future. Release rates from Lake Mendocino will not normally be changed more often that once every three days, to allow the upper and middle Russian River to approach a steady-state condition. This allows the operator to infer the current rate of consumptive uses between the Forks and Healdsburg from the differences in gauged flow rates.

The proposed water right permit terms allow an exception during Critical water supply conditions to increase flows in Dry Creek beyond the normal operational envelope. Thus, during that condition, the operator assumes a target flow from Dry Creek of 200 cfs, which communicates to the upper Russian River algorithm a reduced need for water from Coyote Dam, thereby conserving the water supply pool for upper and middle Russian River basin uses. Conversely, the October Dry Creek target flow under Normal water supply conditions is reduced from 70 to 50 cfs to so that the upper Russian River algorithm increases releases from Lake Mendocino to help purge the flood control pool and reduce a flow rate spike that would otherwise occur as the USACE assumes flood operations control of releases.

There is a biological sensitivity to increasing release rates from Lake Mendocino. These increasing releases needed to meet increased demands could eventually begin to degrade the salmonid rearing habitat in the upper Russian River. Consequently, one of the goals of the proposed flow regime is to balance releases from the two reservoirs to maintain flow levels in both the upper Russian River and Dry Creek that create good rearing habitat for salmonids. To accomplish this, there is a flow rate envelope for the upper and middle Russian River. The envelope is defined by the upper and lower range of flow rates that provide a quality of flow-related habitat consistent with the needs of rearing juvenile salmonids. The upper flow rates are not appropriate as permit terms, but rather are operational goals that the SCWA will strive to meet as future demands increase. The lower range of the flow regulation envelope for the upper and middle Russian River are the minimum flows required by the proposed water rights permit terms listed in Table B-1. The upper boundary of the flow regulation envelope at Healdsburg is listed in Table B-3.

The operational goal of remaining within the flow envelope will be achieved by limiting the amount of Santa Rosa subunit demand that will be met through releases from Lake Mendocino. If necessary, the balance of the demand is then met by increasing the flow rate at the mouth of Dry Creek. In addition to protecting both the upper Russian River salmonid habitat, this also increases the reliability of the water supply in Lake Mendocino.

Table B-3 Healdsburg Upper Flow Envelope in cfs

Jun	Jul	Aug	Sep	Oct	Nov
200	180	160	140	140	170

B.4.0 Minimum Lake Sonoma Releases

The proposed flow regime specifies minimum flow rates for Dry Creek and for the lower Russian River. The Dry Creek minimum flow rates meet the migration and rearing habitat needs of juvenile salmonids in Dry Creek. The Dry Creek minimum flows are listed in Table B-4.

Table B-4 Minimum Stream Flow Requirements for Dry Creek in cfs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal	90	90	90	50	50	25	25	25	25	25	90	90
Dry	75	75	75	50	50	25	25	25	25	25	75	75
Critical	75	75	75	50	50	25	25	25	25	25	75	75

The required minimum flow rate for the lower Russian River generally is the natural flow at Hacienda Bridge. However, there is a specified absolute minimum flow rate of 35 cfs. All of the specified minimum flow rates at Hacienda Bridge refer to a five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum flow requirement). The natural flow of the Russian River at Hacienda Bridge (USGS gauging station Russian River near Guerneville) is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek at the USGS gauging station Austin Creek near Cazadero, California. During periods in which that gauge is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the four-day running average of the gauged flow of Maacama Creek at the USGS gauging station Maacama Creek near Kellogg, California.

Releases from reservoir storage are not required to be made to maintain the natural flow rate once it rises above a specified “transition flow rate.” The transition flow rates for the lower Russian River are listed in Table B-5.

Table B-5 Lower Russian River Transition Flow Rates in cfs

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Normal	125	125	125	150	150	125	125	125	125	125	125	125
Dry	125	125	125	150	150	125	125	125	125	125	125	125
Critical	35	35	35	35	35	35	35	35	35	125	125	125
Dry Spring	125	125	125	150	150	125	125	125	125	125	125	125

An exception to the lower Russian River minimum flow rate requirements applies in order to prevent flooding in the estuary without the need for artificial breaching. When the sand bar at the mouth of the river closes, the required minimum flow at Hacienda Bridge changes from either the natural flow rate or the transition flow rate, whichever is then governing, to a flow rate designated as the Optimal Estuary Inflow (OEI). The minimum required flow then remains at the OEI until the natural flow rate drops below the OEI. At that time, the natural flow rate once again becomes the required minimum flow rate until the natural flow rate declines to the floor value of 35 cfs, where the minimum flow rate remains until the natural flow rate increases back to the point it exceeds 35 cfs. The OEI is defined as the flow at Hacienda Bridge that will result in an estuary water surface elevation stabilized at 7.0 feet. The OEI has been estimated to be approximately 90 cfs. However, the OEI is not constant and changes throughout the year in response to ocean conditions.

B.5.0 Lake Sonoma Operating Criteria

Compared to the operation of Lake Mendocino, the operation of Lake Sonoma is relatively straightforward. The operator makes releases from Lake Sonoma at the rates necessary either to meet the required minimum flow rates listed in Table B-4 (with an operating margin sufficient to allow for variables beyond the control of the SCWA) or the governing minimum flow rate at Hacienda Bridge, whichever requires the larger release rate. During those periods when either the transition flow rates listed in Table B-5, or the absolute minimum flow rate of 35 cfs, governs releases, additional water will be releases at a rate sufficient to provide an operating margin sufficient to allow for variables beyond the control of the SCWA. Unlike at Lake Mendocino, where a change in the rate of release should only be made every three or four days, Lake Sonoma release rate changes can be made more frequently. Since the travel time to the SCWA’s water transmission system intakes for water released from Lake Sonoma is much shorter that that released from Lake Mendocino, daily variations in the lower Russian River flows will be regulated with releases from Lake Sonoma.

B.6.0 Additional Measures

As was the case for the upper and middle Russian River, there is also a flow rate envelope for Dry Creek. The upper range of the flow envelope for Dry Creek is 90 cfs during Normal and Dry water supply conditions. There is no upper range during Critical water supply conditions. The lower range of the flow regulation envelope for Dry Creek is the minimum flows required by the proposed water rights permit terms listed in Table B-4 (with an operating margin sufficient to allow for variables beyond the control of the SCWA).

Since releases must be made from Lake Sonoma at the rates necessary to meet the required lower Russian River minimum flow rates, the only means available to keep Dry Creek flow rates from exceeding the upper range of the flow envelope are physical facilities to limit the need for releases from Lake Sonoma to Dry Creek. These measures could consist of a number of different types of facilities. These include, but are not limited to, aquifer storage and recovery facilities to partially satisfy peak summer water transmission system demands, or a pipeline paralleling Dry Creek to divert water from Lake Sonoma and convey it to the Russian River downstream from the mouth of Dry Creek. While such measures are unnecessary under current water demand conditions, they likely will be necessary in the future.

A series of model runs were performed to define the additional measures that will be necessary in the future to maintain the desired flow levels. Based upon the results of these model studies, additional measures are planned to be constructed that will provide a continuous water supply flow rate during the months of June through September starting at 3 million gallons per day (MGD) when the SCWA water transmission system peak month demand reaches 83 MGD. Further measures are planned to be constructed in stages as shown in Table B-6. The model runs demonstrated that the timely construction of these measures will assure that the desired flow levels in Dry Creek and the upper and middle Russian Rivers will be able to be maintained under all projected future demand conditions.

Table B-6 Implementation Schedule for Additional Measures

SCWA Demand Level (MGD)	Additional Measures (MGD)
73	0
83	0
93	5
104	22
115	37

Flow Proposal
Proposed Water Rights Permit Terms
December 10, 2003

The following revisions to appropriative water rights permits held by the Agency are proposed to implement the flow proposal:

Permit 16596

Term 13 is to be amended to read as follows:

For the protection of fish and wildlife in Dry Creek and the Russian River, unless the elevation of the water level in Lake Sonoma is below 292.0 feet, with reference to the National Geodetic Vertical Datum of 1929, or unless prohibited by the United States Army Corps of Engineers acting under its reserved rights specified in the October 1, 1982 contract between permittee and the United States (or any successor agreement), permittee shall pass through, or release from storage at, Lake Sonoma sufficient water to maintain:

(A) The following minimum flow rates in Dry Creek between Warm Springs Dam and its confluence with the Russian River:

(1) During normal water supply conditions:

90 cfs from January 1 through March 31
50 cfs from April 1 through May 31
25 cfs from June 1 through October 31
90 cfs from November 1 through December 30

(2) During dry or critical water supply conditions:

75 cfs from January 1 through March 31
50 cfs from April 1 through May 31
25 cfs from June 1 through October 31
75 cfs from November 1 through December 31

(B) At the United States Geological Survey stream flow gauging station Russian River near Guerneville, California, to the extent such flows cannot be met by releases from storage at Lake Mendocino under Permit 12947A issued on Application 12919A, a five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum five-day running average flow requirement) that is the lesser of 1) the natural flow rate or 35 cfs, whichever is greater, and 2) the following flow rates:

(1) During normal and dry water supply conditions

125 cfs from October 1 through March 31
150 cfs from April 1 through May 31
125 cfs from June 1 through September 30

(2) During critical water supply conditions

125 cfs from October 1 through December 31
35 cfs from January 1 through September 30

provided, however, during those periods when the Russian River estuary is closed by a sand bar, permittee may reduce the flows at the United States Geological Survey stream flow gauging station Russian River near Guerneville, California below the minimum specified above, if, and to the extent that, such reductions are reasonably necessary so that the water surface elevation in the estuary will not exceed 7.0 feet, with reference to the National Geodetic Vertical Datum of 1929.

For the purposes of the requirements of this term, the following definitions shall apply:

(1) Dry water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

8,000 acre-feet as of January 1
39,200 acre-feet as of February 1
65,700 acre-feet as of March 1
114,500 acre-feet as of April 1
145,600 acre-feet as of May 1
160,000 acre-feet as of June 1

(2) Critical water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

4,000 acre-feet as of January 1
20,000 acre-feet as of February 1
45,000 acre-feet as of March 1
50,000 acre-feet as of April 1
70,000 acre-feet as of May 1
75,000 acre-feet as of June 1

(3) Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

(4) The water supply condition designation for the months of July through December shall be the same as the designation for the previous June. Water supply conditions for January through June shall be redetermined monthly.

(5) Cumulative inflow to Lake Pillsbury is the calculated algebraic sum of releases from Lake Pillsbury, increases in storage in Lake Pillsbury, and evaporation from Lake Pillsbury.

(6) The natural flow of the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek at the

United States Geological Survey gauging station Austin Creek near Cazadero, California. During periods in which this gauge is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the four-day running average of the gauged flow of Maacama Creek at the United States Geological Survey gauging station Maacama Creek near Kellogg, California. These flow ratios may be modified by permittee, upon written application by permittee, supported by at least five years of new stream flow records at the Austin Creek or Maacama Creek gauging stations, so that the above formulas will more accurately estimate the natural flow of the Russian River at the U.S. Geological Survey gauging station Russian River near Guerneville, California. In the preceding sentence, the "natural flow of the Russian River" is that flow that would occur in the Russian River at the referenced gauge if there were no imports of water into the Russian River basin, no releases of stored water and no diversions of water from the Russian River or any of its tributaries.

Permit 12947A

Term 18 is amended to read as follows:

For the protection of fish and wildlife, unless prohibited by the United States Army Corps of Engineers acting within its reserved rights under the water storage space agreement between permittee and the United States (or any successor agreement), permittee shall pass through or release from storage at Lake Mendocino sufficient water to maintain the following minimum flow rates:

(A) A continuous flow rate in the East Fork Russian River from Coyote Valley Dam to its confluence with the Russian River of 25 cfs at all times.

(B) In the Russian River between its confluence with the East Fork Russian River and its confluence with Dry Creek, the following five-day running average flow rates (with the instantaneous flow rate never less than 20 cfs below the specified five-day running average flow requirement):

(1) During normal water supply conditions and when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year exceeds 130,000 acre-feet or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less:

100 cfs from April 1 through May 31
50 cfs from June 1 through October 31
150 cfs from November 1 through March 31

provided, however, if anytime between November 1 through December 31, storage in Lake Mendocino is less than 30,000 acre-feet, then the required minimum flow rate shall be 75 cfs.

(2) During normal water supply conditions and when the combined water in storage, including dead storage, in Lake Pillsbury and Lake Mendocino on May 31 of any year is less than 130,000 acre-feet or 80 percent of the estimated water supply storage capacity of the reservoirs, whichever is less:

100 cfs from April 1 through May 31
50 cfs from June 1 through October 31
75 cfs from November 1 through December 31
150 cfs from January 1 through March 31

(3) During dry water supply conditions:

50 cfs from June 1 through October 31
75 cfs from November 1 through May 31

(4) During critical water supply conditions:

25 cfs during all months.

(C) At the United States Geological Survey stream flow gauging station Russian River near Guerneville, California, a five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum five-day running average flow requirement) that is the lesser of 1) the natural flow rate or 35 cfs, whichever is greater, and 2) the following flow rates:

(1) During normal and dry water supply conditions

125 cfs from October 1 through March 31
150 cfs from April 1 through May 31
125 cfs from June 1 through September 30

(2) During critical water supply conditions

125 cfs from October 1 through December 31
35 cfs from January 1 through September 30

provided, however, during those periods when the Russian River estuary is closed by a sand bar, permittee may reduce the flows at the United States Geological Survey stream flow gauging station Russian River near Guerneville, California below the minimum specified above, if, and to the extent that, such reductions are reasonably necessary so that the water surface elevation in the estuary will not exceed 7.0 feet, with reference to the National Geodetic Vertical Datum of 1929.

For the purposes of the requirements of this term, the following definitions shall apply:

(1) Dry water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

8,000 acre-feet as of January 1

39,200 acre-feet as of February 1
65,700 acre-feet as of March 1
114,500 acre-feet as of April 1
145,600 acre-feet as of May 1
160,000 acre-feet as of June 1

(2) Critical water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

4,000 acre-feet as of January 1
20,000 acre-feet as of February 1
45,000 acre-feet as of March 1
50,000 acre-feet as of April 1
70,000 acre-feet as of May 1
75,000 acre-feet as of June 1

(3) Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

(4) The water supply condition designation for the months of July through December shall be the same as the designation for the previous June. Water supply conditions for January through June shall be redetermined monthly.

(5) Cumulative inflow to Lake Pillsbury is the calculated algebraic sum of releases from Lake Pillsbury, increases in storage in Lake Pillsbury, and evaporation from Lake Pillsbury.

(6) Estimated water supply storage capacity is the reservoir volume below elevation 1,828.3 feet in Lake Pillsbury and below elevation 749.0 feet in Lake Mendocino. Both elevations refer to the National Geodetic Vertical Datum of 1929. The volume shall be determined using the most recent reservoir volume surveys made by the U.S. Geological Survey, U.S. Army Corps of Engineers, or other responsible agency.

(7) The natural flow of the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek at the United States Geological Survey gauging station Austin Creek near Cazadero, California. During periods in which this gauge is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the four-day running average of the gauged flow of Maacama Creek at the United States Geological Survey gauging station Maacama Creek near Kellogg, California. These flow ratios may be modified by permittee, upon written application by permittee, supported by at least five years of new stream flow records at the Austin Creek or Maacama Creek gauging stations, so that the above formulas will more accurately estimate the natural flow of the Russian River at the U.S. Geological Survey gauging station Russian River near Guerneville, California. In the preceding sentence, the "natural flow of the Russian River" is that flow that would occur in the Russian River at the referenced gauge if there were no

imports of water into the Russian River basin, no releases of stored water and no diversions of water from the Russian River or any of its tributaries.

Permit 12949

Term 15 is amended to read as follows:

For the protection of fish and wildlife, and the maintenance of recreation in the Russian River, permittee shall allow sufficient water to bypass the points of diversion to maintain the following minimum flows at the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California:

A five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum five-day running average flow requirement) that is the lesser of 1) the natural flow rate or 35 cfs, whichever is greater, and 2) the following flow rates:

(1) During normal and dry water supply conditions

125 cfs from October 1 through March 31
150 cfs from April 1 through May 31
125 cfs from June 1 through September 30

(2) During critical water supply conditions

125 cfs from October 1 through December 31
35 cfs from January 1 through September 30

provided, however, during those periods when the Russian River estuary is closed by a sand bar, permittee may reduce the flows at the United States Geological Survey stream flow gauging station Russian River near Guerneville, California below the minimum specified above, if, and to the extent that, such reductions are reasonably necessary so that the water surface elevation in the estuary will not exceed 7.0 feet, with reference to the National Geodetic Vertical Datum of 1929.

For the purposes of the requirements of this term, the following definitions shall apply:

(1) Dry water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

8,000 acre-feet as of January 1
39,200 acre-feet as of February 1
65,700 acre-feet as of March 1
114,500 acre-feet as of April 1
145,600 acre-feet as of May 1
160,000 acre-feet as of June 1

(2) Critical water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

4,000 acre-feet as of January 1
20,000 acre-feet as of February 1
45,000 acre-feet as of March 1
50,000 acre-feet as of April 1
70,000 acre-feet as of May 1
75,000 acre-feet as of June 1

(3) Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

(4) The water supply condition designation for the months of July through December shall be the same as the designation for the previous June. Water supply conditions for January through June shall be redetermined monthly.

(5) Cumulative inflow to Lake Pillsbury is the calculated algebraic sum of releases from Lake Pillsbury, increases in storage in Lake Pillsbury, and evaporation from Lake Pillsbury.

(6) The natural flow of the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek at the United States Geological Survey gauging station Austin Creek near Cazadero, California. During periods in which this gauge is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the four-day running average of the gauged flow of Maacama Creek at the United States Geological Survey gauging station Maacama Creek near Kellogg, California. These flow ratios may be modified by permittee, upon written application by permittee, supported by at least five years of new stream flow records at the Austin Creek or Maacama Creek gauging stations, so that the above formulas will more accurately estimate the natural flow of the Russian River at the U.S. Geological Survey gauging station Russian River near Guerneville, California. In the preceding sentence, the "natural flow of the Russian River" is that flow that would occur in the Russian River at the referenced gauge if there were no imports of water into the Russian River basin, no releases of stored water and no diversions of water from the Russian River or any of its tributaries.

Permit 12950

Term 15 is amended to read as follows:

For the protection of fish and wildlife, and the maintenance of recreation in the Russian River, permittee shall allow sufficient water to bypass the points of diversion to maintain the following minimum flows at the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California:

A five-day running average flow rate (with the instantaneous flow rate never less than 10 cfs below the specified minimum five-day running average flow requirement) that is the lesser of 1) the natural flow rate or 35 cfs, whichever is greater, and 2) the following flow rates:

(1) During normal and dry water supply conditions

125 cfs from October 1 through March 31
150 cfs from April 1 through May 31
125 cfs from June 1 through September 30

(2) During critical water supply conditions

125 cfs from October 1 through December 31
35 cfs from January 1 through September 30

provided, however, during those periods when the Russian River estuary is closed by a sand bar, permittee may reduce the flows at the United States Geological Survey stream flow gauging station Russian River near Guerneville, California below the minimum specified above, if, and to the extent that, such reductions are reasonably necessary so that the water surface elevation in the estuary will not exceed 7.0 feet, with reference to the National Geodetic Vertical Datum of 1929.

For the purposes of the requirements of this term, the following definitions shall apply:

(1) Dry water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

8,000 acre-feet as of January 1
39,200 acre-feet as of February 1
65,700 acre-feet as of March 1
114,500 acre-feet as of April 1
145,600 acre-feet as of May 1
160,000 acre-feet as of June 1

(2) Critical water supply conditions exist when cumulative inflow to Lake Pillsbury beginning on October 1 of each year is less than:

4,000 acre-feet as of January 1
20,000 acre-feet as of February 1
45,000 acre-feet as of March 1
50,000 acre-feet as of April 1
70,000 acre-feet as of May 1
75,000 acre-feet as of June 1

(3) Normal water supply conditions exist in the absence of defined dry or critical water supply conditions.

(4) The water supply condition designation for the months of July through December shall be the same as the designation for the previous June. Water supply conditions for January through June shall be redetermined monthly.

(5) Cumulative inflow to Lake Pillsbury is the calculated algebraic sum of releases from Lake Pillsbury, increases in storage in Lake Pillsbury, and evaporation from Lake Pillsbury.

(6) The natural flow of the Russian River at the United States Geological Survey gauging station Russian River near Guerneville, California is defined as 11.77 times the four-day running average of the gauged flow of Austin Creek at the United States Geological Survey gauging station Austin Creek near Cazadero, California. During periods in which this gauge is malfunctioning or otherwise not available, the natural flow is defined as 24.89 times the four-day running average of the gauged flow of Maacama Creek at the United States Geological Survey gauging station Maacama Creek near Kellogg, California. These flow ratios may be modified by permittee, upon written application by permittee, supported by at least five years of new stream flow records at the Austin Creek or Maacama Creek gauging stations, so that the above formulas will more accurately estimate the natural flow of the Russian River at the U.S. Geological Survey gauging station Russian River near Guerneville, California. In the preceding sentence, the "natural flow of the Russian River" is that flow that would occur in the Russian River at the referenced gauge if there were no imports of water into the Russian River basin, no releases of stored water and no diversions of water from the Russian River or any of its tributaries.

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APPENDIX C

EVALUATION CRITERIA

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Term	*Definition*
BA	Biological Assessment
BMP	best management practice
BOD	biological oxygen demand
C	Celsius
CDFG	California Department of Fish and Game
CRWQCB	California Regional Water Quality Control Board
cfs	cubic-feet per second
cm	centimeter(s)
cm/hr	centimeters per hour
CVFF	Coyote Valley Fish Facility
d_{50}	median diameter
DCFH	Don Clausen Fish Hatchery (also known as Warm Springs Fish Hatchery)
DO	dissolved oxygen
EPA	U.S. Environmental Protection Agency
Estuary	Russian River Estuary
ESU	Evolutionarily Significant Unit
fps	feet per second
HSI	Habitat Suitability Index
ILT	Incipient Lethal Temperature
JTU	Jackson turbidity unit
mg/l	Milligram(s) per liter
mm	millimeter(s)
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
MWAT	maximum weekly average temperature
NATURES	Natural Rearing Enhancement System

Term	*Definition*
NCRWQCB	Regional Water Quality Control Board, North Coast Region
NMFS	National Marine Fisheries Service, now known as NOAA Fisheries
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System
NTU	Nephelometric turbidity unit
RMA	Resource Management Associates
RRWQM	Russian River Water Quality Model
SAR	smolt-to-adult survival
SCWA	Sonoma County Water Agency
UIL_{50}	upper incipient lethal temperature at which 50 percent of experimental organisms die within a given timeframe
USACE	U.S. Army Corps of Engineers
USFWS	U.S. Fish and Wildlife Service
USGS	U.S. Geological Survey
WSE	water surface elevation
YOY	young of the year

C.1.1 INTRODUCTION

This appendix to the Russian River Biological Assessment (BA) presents the evaluation criteria used to analyze the potential for effects to the Russian River populations of coho salmon, steelhead, and Chinook salmon as a result of the proposed project. It describes the models used to predict the effects of some alternative operations and describes additional studies that have been conducted to assess project effects.

ENTRIX, Inc. developed evaluation criteria to assess or scale the effects of U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (SCWA), and Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) activities in a semi-quantitative way. The criteria provide the basis for an objective evaluation of the various activities and facilities that are included in the BA. They provide the basis for assigning an effect score for such effects as water temperature, habitat, sedimentation, and scour.

Evaluation criteria are based on a review of the available information and initial consultation with appropriate technical resources including staff from USACE, SCWA, National Oceanic and Atmospheric Administration (NOAA) Fisheries, California Department of Fish and Game (CDFG), and others. Preliminary criteria were presented to USACE, SCWA, CDFG, NOAA Fisheries, and the North Coast Regional Water Quality Control Board (NCRWQCB) by ENTRIX, Inc. scientists during a meeting. The criteria, the basis for the criteria, and how they would be applied were explained at this meeting. Comments on the proposed criteria were addressed.

An objective basis for assessing effects to the listed fish and their habitats was identified. Effect assessment is based on a consistent set of evaluation categories and criteria for life-history stages of coho salmon, steelhead, and Chinook salmon and their habitats by reach of the Russian River, Dry Creek, and tributaries. If an effect is common among project components, the same criteria are applied. A consistent set of scoring criteria simplifies comparisons between facilities, locations, and effects. The scoring process is automated for hydrological time series and model outputs. The scoring system is set up on a relative scale of 0 to 5. A score of 0 indicates an effect that could result in population failure or substantial adverse modification to habitat, and a score of 5 indicates no negative effect or a beneficial effect. A separate scoring system is set up for each species and life-history stage. Each species/life-history stage group is evaluated separately. The score is applied only on the months when the species/life-history stage being evaluated would be expected to be present in the river.

The criteria provide a consistent means of evaluation of a specific effect by species and life-history stage, and location, as appropriate. For instance, coho salmon may not use some areas in the watershed for juvenile rearing so there would be no reason to evaluate these areas for an effect on coho salmon as long as the facility or operation component had only localized effects.

C.1.2 Physical Habitat-Related Criteria

Habitat may be affected by a number of factors. These include flow, water temperature, water quality, and sediment, among others. Some habitat factors are related to the configuration of the channel and its characteristics, while others affect the fish regardless of location (e.g., dissolved oxygen [DO]). Streamflow affects fish habitat for spawning/incubation and rearing, as well as fish passage. This section addresses flow-related physical habitats and criteria to evaluate those habitats.

Winzler and Kelly (1978) conducted a systematic survey of existing and potential fish habitat in the mainstem Russian River and Dry Creek. Minimum instream flows under D1610 were determined, in part, based on this work. Information was developed for flow-related effects on spawning and rearing habitat by Winzler and Kelly (1978) and by CDFG (Baracco 1977). Because this information is more than 20 years old and channel conditions have changed in the intervening period, this information was not used in developing evaluation criteria for this BA.

In fall 2001, ENTRIX, Inc. developed the Russian River and Dry Creek Flow-Related Habitat Assessment (Flow Habitat Study, Appendix F) (ENTRIX, Inc. 2003) in consultation with USACE, SCWA, NOAA Fisheries, CDFG, and the California Regional Water Quality Control Board (CRWQCB) (see Appendix F). This study was developed as part of the effort to evaluate flow-related habitat under D1610 and other potential flow regimes, and to develop information regarding how fish habitat changes with flow. ENTRIX, Inc., NOAA Fisheries, USACE, and SCWA developed a semi-quantitative analysis of flow-related habitat needs. Study objectives centered on the management of rearing habitat because the study participants believe fry and juvenile rearing may limit fish production in the study area. Habitat quality and quantity were determined by considering a combination of field measurements at representative cross-sectional transects and observations, and qualitative analysis of the available habitat at different evaluation flows by a team of professional fishery scientists from the participating entities above.

The Flow Habitat Study evaluated habitat availability at alternative flows scenarios for juvenile and fry life-history stages of the three listed species of anadromous salmonids in Dry Creek and the Russian River. In addition, spawning habitat for steelhead and Chinook salmon was evaluated for the Russian River, but not for Dry Creek. The study area included Dry Creek between Warm Springs Dam and the Russian River confluence, and the Russian River between the Forks and the City of Cloverdale. Habitat was evaluated over a range of releases from Warm Springs Dam and Coyote Valley Dam. Russian River sites were evaluated during stable dam releases of 125 cfs, 190 cfs, and 275 cfs. Dry Creek sites were evaluated during stable dam release flows of 47 cfs, 90 cfs, and 130 cfs.

Generally speaking, the lower flow levels evaluated provided greater amounts of suitable and optimal rearing habitat than the higher flow levels. On Dry Creek this was particularly true for steelhead fry and juveniles. The low and intermediate flow levels on Dry Creek provided similar amounts of habitat for fry and juvenile Chinook salmon. The amount of habitat at the 130 cfs flow level on Dry Creek provided much less suitable and optimal habitat for both species than either of the two lower flows. In most Dry Creek study sites, at least 25 percent of the stream area provided optimal habitat for steelhead fry and juveniles when flows were either 47 cfs or 90 cfs; most of these cases occurred at the lowest flow. Dry Creek also provided ample nursery habitat for Chinook salmon; at least 25 percent of the stream area was rated optimal at flows of 47 cfs and 90 cfs.

On the Russian River, the lowest observed flow provided the greatest amount of habitat for both Chinook salmon and steelhead fry and juveniles. The intermediate flow provided the greatest amount of habitat for spawners of both species. On the Russian River the difference in the amount of habitat was more similar among the three flow levels and there was not the tremendous decrease in habitat at the highest flow level as was observed in Dry Creek.

Flow criteria were developed based in part on the Flow Habitat Study, described above, as well as conversations with biologists familiar with the Russian River, and professional judgment. Flow evaluation criteria for the effects of instream flow on habitat availability are presented for each species and each life-history stage (Tables C-1 and C-2). These criteria were applied in an analysis of flow in Dry Creek and the mainstem Russian River.

To assess flow-related habitat, flow criteria will be applied to predicted flows from the Russian River System Model (RRSM) under various flow scenarios. This model was developed by SCWA. Flows were modeled at various locations in the Russian River and Dry Creek.

Table C-1 Flow Evaluation Criteria for the Russian River by Species and Life-History Stage

Coho Salmon	**Nov 1 to Jan 31**
Habitat Score	**Q (cfs) Upmigration**
0	≤ 50
1	> 50 ≤ 75
2	> 75 ≤ 100
3	>100 ≤ 125
4	> 125 ≤180
5	> 180 ≤ 400
4	> 400 ≤ 800
3	> 800 ≤ 2000
2	> 2000 ≤ 4000
1	> 4000
0	

Table C-1 Flow Evaluation Criteria for the Russian River by Species and Life-History Stage (Continued)

Coho Salmon Habitat Score	Nov 1 to Jan 31 Q (cfs) Upmigration			
Chinook Salmon **Habitat Score**	**Aug 15 to Jan 15** **Q (cfs)** **Upmigration**	**Nov 1 to Jan 31** **Q (cfs)** **Spawning**	**Feb 1 to Apr 30** **Q (cfs)** **Fry Rearing**	**Apr 1 to Jun 30** **Q (cfs)** **Juvenile Rearing**
0	≤ 50	≤ 25	≤ 0	≤ 0
1	> 50 ≤ 75	> 25 ≤ 100	> 0 ≤ 20	> 0 ≤ 20
2	> 75 ≤ 100	> 100 ≤ 130	> 20 ≤ 40	> 20 ≤ 50
3	>100 ≤ 125	> 130 ≤ 150	> 40 ≤ 80	> 50 ≤ 100
4	> 125 ≤180	> 150 ≤ 190	> 80 ≤ 115	> 100 ≤115
5	> 180 ≤ 400	> 190 ≤ 210	> 115 ≤ 135	> 115 ≤ 145
4	> 400 ≤ 800	> 210 ≤ 300	> 135 ≤ 175	> 145 ≤ 190
3	> 800 ≤ 2000	> 300 ≤ 400	> 175 ≤ 250	> 190 ≤ 275
2	> 2000 ≤ 4000	> 400 ≤ 700	> 250 ≤ 500	> 275 ≤ 1000
1	> 4000	> 700 ≤ 2500	> 500 ≤ 1500	> 1000 ≤ 2500
0		> 2500	> 1500	> 2500
Steelhead **Habitat Score**	**Jan 1 to Mar 31** **Q (cfs)** **Upmigration**	**Jan 1 to Apr 30** **Q (cfs)** **Spawning**	**Mar 1 to Jun 30** **Q (cfs)** **Fry Rearing**	**Summer** **Q (cfs)** **Juvenile Rearing**
0	≤ 50	≤ 25	≤ 0	≤ 0
1	> 50 ≤ 75	> 25 ≤ 70	> 0 ≤ 20	> 0 ≤ 20
2	> 75 ≤ 100	> 70 ≤ 100	> 20 ≤ 40	> 20 ≤ 50
3	>100 ≤ 125	> 100 ≤ 130	> 40 ≤ 80	> 50 ≤ 80
4	> 125 ≤180	> 130 ≤ 180	> 80 ≤ 100	> 80 ≤ 115
5	> 180 ≤ 400	> 180 ≤ 200	> 100 ≤ 125	> 115 ≤ 145
4	> 400 ≤ 800	> 200 ≤ 250	> 125 ≤ 150	> 145 ≤ 190
3	> 800 ≤ 2000	> 250 ≤ 350	> 150 ≤ 200	> 190 ≤ 275
2	> 2000 ≤ 4000	> 350 ≤ 700	> 200 ≤ 500	> 275 ≤ 1000
1	> 4000	> 700 ≤ 2500	> 500 ≤ 1500	> 1000 ≤ 2500
0		> 2500	> 1500	> 2500

Table C-2 Flow Evaluation Criteria for Dry Creek by Species and Life-History Stage

Coho Salmon Habitat Score[1]	Nov 1 to Jan 31 Q (cfs) Upmigration	Dec 1 to Feb 15 Q (cfs) Spawning	Feb 1 to Apr 30 Q (cfs) Fry Rearing	Summer Q (cfs) Juvenile Rearing
0	≤ 10	≤ 5	≤ 0	≤ 0
1	>10 ≤ 20	> 5 ≤ 20	> 0 ≤ 10	> 0 ≤ 10
2	> 20 ≤ 30	> 20 ≤ 30	> 10 ≤ 20	> 10 ≤ 25
3	> 30 ≤ 90	> 30 ≤ 45	> 20 ≤ 30	> 25 ≤ 45
4	> 90 ≤ 125	> 45 ≤ 60	> 30 ≤ 40	> 45 ≤ 60
5	> 125 ≤ 200	> 60 ≤ 80	> 40 ≤ 70	> 60 ≤ 85
4	> 200 ≤ 250	> 80 ≤ 100	> 70 ≤ 90	> 85 ≤ 100
3	> 250 ≤ 325	> 100 ≤ 125	> 90 ≤ 130	> 100 ≤ 120
2	> 325 ≤ 400	> 125 ≤ 250	> 130 ≤ 200	> 120 ≤ 200
1	> 400 ≤ 500	> 250 ≤ 800	> 200 ≤ 500	> 200 ≤ 500
0	> 500	> 800	> 500	> 500

Chinook Salmon Habitat Score[1]	Aug 15 to Jan 15 Q (cfs) Upmigration	Nov 1 to Jan 31 Q (cfs) Spawning	Feb 1 to Apr 30 Q (cfs) Fry Rearing	Apr 1 to Jun 30 Q (cfs) Juvenile Rearing
0	≤ 10	≤ 5	≤ 0	≤ 0
1		> 5 ≤ 25	> 0 ≤ 10	> 0 ≤ 10
2	> 10 ≤ 45	> 25 ≤ 40	> 10 ≤ 20	> 10 ≤ 25
3	> 45 ≤ 60	> 40 ≤ 60	> 20 ≤ 30	> 25 ≤ 45
4	> 60 ≤ 90	> 60 ≤ 80	> 30 ≤ 45	> 45 ≤ 60
5	> 90 ≤ 125	> 80 ≤ 105	> 45 ≤ 60	> 60 ≤ 90
4	> 125 ≤ 200	> 105 ≤ 130	> 60 ≤ 90	> 90 ≤ 100
3	> 200 ≤ 325	> 130 ≤ 150	> 90 ≤ 110	> 100 ≤ 110
2	> 325 ≤ 400	> 150 ≤ 250	> 110 ≤ 150	> 110 ≤ 200
1	> 400 ≤ 500	> 250 ≤ 1300	> 150 ≤ 500	> 200 ≤ 500
0	> 500	> 1300	> 500	> 500

Steelhead Habitat Score[1]	Jan 1 to Mar 31 Q (cfs) Upmigration	Jan 1 to Apr 30 Q (cfs) Spawning	Mar 1 to Jun 30 Q (cfs) Fry Rearing	Summer Q (cfs) Juvenile Rearing
0	≤ 10	≤ 5	≤ 0	≤ 0
1	>10 ≤ 20	> 5 ≤ 20	> 0 ≤ 5	> 0 ≤ 5
2	> 20 ≤ 30	> 20 ≤ 30	> 5 ≤ 15	> 5 ≤ 15
3	> 30 ≤ 90	> 30 ≤ 60	> 14 ≤ 30	> 14 ≤ 30
4	> 90 ≤ 125	> 60 ≤ 80	> 30 ≤ 40	> 30 ≤ 40
5	> 125 ≤ 200	> 80 ≤ 110	> 40 ≤ 55	> 40 ≤ 55
4	> 200 ≤ 250	>110 ≤ 135	> 55 ≤ 70	> 55 ≤ 70
3	> 250 ≤ 325	> 135 ≤ 150	> 70 ≤ 90	> 70 ≤ 90
2	> 325 ≤ 400	> 150 ≤ 250	> 90 ≤ 110	> 90 ≤ 110
1	> 400 ≤ 500	> 250 ≤ 1300	> 110 ≤ 500	> 110 ≤ 500
0	> 500	> 1300	> 500	> 500

[1] A score of “5” is the highest, “1” is the lowest.

Because of the different channel dimensions and channel morphology, separate flow criteria were developed for the Russian River and Dry Creek. In the following, the criteria for the Russian River are discussed first, followed by the criteria for Dry Creek

Russian River

Upstream Migration

Upstream migration was not assessed during the Flow Habitat Study. Upstream migration can be affected when flows so low that depths in riffle habitats are too shallow for fish to swim upstream because they cannot submerge their bodies completely, or when velocities become so high that fish cannot move upstream against these velocities. Conversations with biologists knowledgeable about the Russian River watershed indicated that, in the Russian River, the optimal flows for upstream passage of salmonids would range from about 150 to 400 cfs. In addition, at 100 cfs the fish would likely not be able to submerge completely, but may still be able to move upstream through the riffle. At the high flows, 4,000 cfs was thought to be a flow that would produce velocities sufficient to severely impede migration because of high velocities. However, even at this flow, it was recognized that there would probably still be areas where velocities were low enough for fish to find ways to move upstream.

Based on this information, flows between 180 and 400 cfs were considered optimal for migration, and received a score of 5. A flow of 50 was considered completely impassible because of shallow water depths and received a score of 0. A score of 0 was not assigned at high flows for the reason given above, but all flows over 4,000 cfs were assigned a score of 1, indicating that passage would be severely impaired. Between the optimal range of flows and the unsuitable flows identified above, scores were assigned to describe relative degrees of passage impairment. The flow ranges assigned to each score category are provided in Table C-1.

Spawning

Spawning criteria were developed for steelhead and Chinook salmon on the Russian River. Criteria were not developed for coho salmon as they are not thought to spawn in the Russian River. Spawning habitat for steelhead and Chinook salmon was assessed in the Russian River during the Flow Habitat Study. The Flow Assessment team concluded that the middle flow release of 190 cfs provided the best quality and highest quantity of habitat for spawning for both species. The lowest flow (125 cfs release) resulted in the better spawning habitat than the highest flow release for steelhead, while the reverse was true for Chinook salmon. The decrease in habitat quantity and quality was generally not great compared to the amount available at the middle flow release.

Based on the results of the Flow Habitat Study and professional judgment, flow scoring criteria for the Russian River considered flows of 190 to 210 cfs optimal (score of 5) for Chinook salmon spawning and 180 to 200 as optimal for steelhead spawning. Spawning habitat decreases as flows move away from this range. As flows become lower, depths may become too shallow and velocities too low for spawning. As flows exceed the optimal range, depths and velocities become too great for spawning. Flows of 25 cfs or less were considered too low for successful spawning for both species on the Russian River and given a score of 0. Flows of more than 2,500 cfs would result in velocities that were generally too high for spawning of both species (as well as depths that were too deep) and also given a score of 0. Between the flows for optimal and completely unsuitable habitat (score of 0) ranges of flow were assigned scores based on their relative suitability for spawning. These flow ranges are provided in Table C-1.

Rearing Habitat

Rearing habitat was assessed for fry and juvenile steelhead and Chinook salmon on the Russian River during the Flow Habitat Study. Coho salmon do not rear in the mainstem Russian River and therefore habitat was not assessed nor were criteria developed for coho salmon rearing lifestages. This study found that the lowest flow (125 cfs) provided the best conditions for both of these rearing lifestages for both species. Rearing habitat value decreased gradually as flows increased, and was substantially reduced at the highest study flow (275 cfs release flow) relative to the lowest flow level. For these lifestages, habitat would continue to be available in some areas even at very low flows. However, as flow levels decrease, these fish would be crowded into ever smaller areas, forced into pools with potential predators, and be exposed to warmer water temperatures and decreased water quality. Habitat would continue to be available, however, for some fish. Based on this, a flow of 0 was assigned a score of 0.

As flows increase above the optimal range, velocities begin to increase to levels higher than optimal. Juveniles and fry are forced to seek out areas of reduced velocity. As flows continue to increase, these areas become smaller and smaller, crowding this fish into smaller areas of suitable habitat. At flows of 1,500 cfs for fry and 2,500 cfs for juveniles, velocities become high enough that there is little area with suitable velocities left for fry and juveniles to live in. These flows were assigned a score of 0 for the two lifestages. Between the range of optimal flows and the flows that provide little or no habitat, scores were assigned that reflect the relative value of different flow ranges as rearing habitat. These scores are provided in Table C-1.

Dry Creek

The flow ranges providing habitat for the various lifestages in Dry Creek are lower than those in the Russian River because of the smaller size of the channel. However, the scoring criteria were derived in the same manner as those for the Russian River. The Flow Habitat Study evaluated fry and juvenile rearing habitat for all three anadromous salmonid species in Dry Creek (coho salmon, steelhead, and Chinook salmon). Habitat conditions were not evaluated for spawning as part of this study. For both spawning and upstream migration, the scoring criteria are based upon discussions with biologists knowledgeable about the Russian River watershed and professional judgment.

Upstream Migration

For upstream migration, flows of 90 to 125 cfs were considered optimal for upstream migration. Flows of 10 cfs or less were considered to provide depths too shallow for passage over riffles, and flows of more than 500 cfs were thought to provide velocities too high for fish to migrate upstream. Between the optimal range and the flows that prevented passage, scores were assigned to describe the relative value of different flow ranges for passage. Flows between 30 and 325 cfs were thought to provide acceptable conditions for passage and were scored 3 or higher. As flows declined below 30 cfs, depths become too shallow for passage, and passage becomes increasingly difficult the more flows decline. At flows of 325 cfs there are likely areas in the riffles where velocities are still passable and most fish would be able to migrate upstream. As flows increase further, velocities become higher and passage becomes increasingly more difficult. The range of flows within each score category for upstream migration are provided in Table C-2.

Spawning

Spawning habitat was considered to be optimal at flows from 60 to 80 cfs for coho salmon, 80 to 105 cfs for Chinook salmon, and 80 to 110 cfs for steelhead. Flows of 5 cfs were considered to provide no suitable spawning habitat for any of the species and given a score of 0. Velocities were considered to become unacceptably high for spawning at 800 cfs for coho salmon and 1,300 cfs for Chinook salmon and steelhead. These flows were given a score of 0 for the respective species. The range of flows resulting in intermediate scores is provided in Table C-2.

Rearing

Fry and juvenile rearing habitat was assessed at flows of 47, 90, and 130 cfs as part of the Flow-Habitat Study. This study found that the lowest flow level provided the best habitat (greatest quantity and best quality) for both juvenile and fry of all three species. At 90 cfs, habitat was somewhat worse than that at the lowest flow level, but at the 130 cfs release, habitat was severely reduced. Fry habitat was considered optimal at flows ranging from 40 to 70 cfs for coho salmon, 45 to 60 cfs for Chinook salmon, and 40 to 55 cfs for steelhead. Flows of 0 cfs were given a score of 0. Low flows may continue to provide habitat in pools; however, water quality and temperature conditions may deteriorate at extremely low flows. Additionally, food-producing areas (riffles and runs) would be reduced in size. As flows increase above the optimal range of flows, high velocities become an increasing problem. At 500 cfs, velocities are too high for fry and juvenile rearing for all three species and flows of 500 or more are scored a 0. The flow ranges assigned to intermediate score values for salmonid rearing are described in Table C-2.

C.1.3 WATER QUALITY CRITERIA

Water quality parameters include temperature, DO, and turbidity.

C.1.3.1 TEMPERATURE

Water temperature directly affects an organism's ability to survive, grow, and reproduce. It is one of the most important factors controlling the production and distribution of freshwater fish. In general, the growth rate and physiological performance (e.g., swimming ability) of salmonids increases as a function of temperature up to some tolerance level and then declines as temperatures continue to climb. Excessively high, sustained temperatures reduce growth and physiological performance, increase susceptibility to disease, and may ultimately result in death. Factors such as DO levels and food availability affect temperature tolerance of salmonids.

Published temperature requirements for salmonids are characterized as preferred, optimum, or tolerable. The term "preferred" refers to the temperature range fish species most frequently occupy when placed in a thermal gradient, and are often considered a reasonable estimator of beneficial/optimal temperatures. The optimum temperature range is that at which feeding activity and physiological response is most efficient (McCullough 1999). Tolerable temperature ranges are those in which salmonids can survive.

To determine upper lethal temperatures, two basic methods are used in studies: 1) critical thermal maximum (CTM) and 2) incipient lethal temperature (ILT). The CTM method slowly heats water to find the upper tolerance levels for fish, while the ILT method abruptly transfers fish to warmer water. Temperature thresholds for tolerable ranges are determined experimentally by placing fish in different water temperatures and measuring mortality rates.

The temperatures that may be considered deleterious for a fish species depend on the duration of exposure. The US Environmental Protection Agency (EPA 2001) cites National Academy of Sciences (NAS) (1972) recommendations for water temperature exposure for protection of aquatic life that specify maximum acceptable temperatures for prolonged exposures (>1 week), winter maximum temperatures, short-term exposure to extreme temperature, and suitable reproduction and development temperatures. Lethal effects are thermal effects that cause direct mortality within an exposure period of less than 1 week. Survival rates based on amount of time exposed and temperature of exposure are extremely well described in the scientific literature. The upper incipient lethal temperature (UILT) is an exposure temperature, given a previous acclimation to a constant acclimation temperature, that 50 percent of the fish can tolerate for seven days (Elliott 1981). Alternatively, UILT at a particular acclimation temperature has been determined as an exposure temperature producing 50 percent survival within 1,000 minutes (Brett 1952, Elliott 1981) or 24 hours (Wedemeyer and McLeay 1981, Armour 1990). For salmonids, a survey of the literature indicates that acclimation temperatures above approximately 68°F (20°C) produce similar UILT values, although very small increases in UILT can occur at up to a 75.2°F (24°C) acclimation temperature. Consequently, it can be safely assumed that any UILT study in which acclimation temperature was 68°F (20°C) will produce a UILT nearly identical to the UUILT (ultimate UILT). UILTs reported by EPA (2001) for rainbow trout range from 24° to 26.9°C.

While these experimental values are useful for assessing temperature requirements, they do not take into account salmonid adaptations to regional temperature regimes. Furthermore, salmonids can withstand short-term exposure to temperatures higher than those needed for longer term growth or survival without significant negative effects.

Optimal, tolerable, and lethal water temperature ranges vary by species and by life-history stage (e.g., salmonid embryos are less tolerant of high temperatures than juveniles). For instance, adult salmon and steelhead may delay upstream spawning migrations if water temperatures are too warm or too cold. In cool temperatures, gamete maturation is slowed, which can lead to delays in spawning. Although salmonids have some natural flexibility in migration schedules, human-induced changes in temperature regime may produce unfavorable conditions for native stocks to persist and drive them to extinction if temperature changes become too extreme.

Embryo development is also sensitive to extremes in water temperature. In general, there are high and low threshold values beyond which embryo mortality increases. Embryos can survive at temperatures near lower threshold values, provided initial development of the embryo has progressed to a stage that is tolerant of cold water.

Finally, water temperature has a large impact on the metabolism (since salmonids are cold-blooded) and growth of juvenile salmonids. While there is an optimum temperature range at which growth is maximized, most salmonid species can grow fairly quickly at higher than optimal temperatures, given an adequate food supply. If food is not plentiful enough to meet elevated metabolic needs of the fish in higher water temperatures, fish could experience a slower growth rate or weight loss.

There are no regional or Russian River-specific temperature data to assess the effects of temperature on coho salmon, steelhead, and Chinook salmon. Stream temperatures that restrict salmonids vary with species and by geographic region. Critical temperatures that limit production and survival also vary widely in the literature.

The NCRWQCB reviewed the water quality objective for temperature in the Russian River basin to protect aquatic life, including listed species. This process included an in-depth analysis of salmonid water temperature tolerances. The NCRWQCB staff report (NCRWQCB 2000) identified maximum temperatures and preferred temperature ranges for each species and lifestage. The report identified five alternatives for the revision of the water quality objective for temperature. These alternatives are undergoing further review, and a final selection has not been made.

The following sections document preferred water temperatures and thermal tolerance ranges for coho salmon, steelhead, and Chinook salmon. These values are used to develop evaluation criteria for the effects of temperature for four different life-history stages: upstream migration, adult spawning, incubation of embryos, and rearing of juveniles. Literature values and citations used to develop temperature evaluation criteria are listed in Attachment 1.

C.1.3.1.1 Temperature Criteria

To quantify the effect of temperature change on salmonid persistence, evaluation criteria that assign scores to various temperature ranges were developed. The temperature criteria are based on the peer-reviewed literature values discussed below and are consistent with recently-conducted temperature reviews (NCRWQCB 2000, Myrick and Cech 2001, Sullivan et al. 2000). In developing the criteria for the Russian River, literature values based on California stocks were given preference.

The effect of temperature on a given life-history stage is quantified using scores from 0 to 5. Preferred temperatures are based on optimum ranges from the literature and are assigned a score of 5. ILTs are given a score of 0, despite the fact that these are the lowest magnitude temperatures that can result in mortality (i.e., upper ILT at which 50 percent of experimental organisms die within a given time-frame [UIL_{50}]). The distribution of scores between 0 and 5 is based either on literature values, or in cases where no literature values exist, is interpolated between known values (see Tables A to D in Attachment 1). The distribution of criteria values is based on U.S. Fish and Wildlife Service (USFWS) Habitat Suitability Index (HSI) curves to the extent feasible.

Most of the literature values used to develop the criteria are based on studies conducted in the Pacific Northwest, and may not reflect upper temperature limits of salmonids in the southern portion of their range. Salmonids in the warmer portion of their range may have local adaptations to their regional temperature. For example, steelhead can survive in higher summer temperatures if food is plentiful enough to support a higher metabolic rate (Smith and Li 1983). If primary and secondary production is high, then a numeric temperature objective specific to the Russian River may be higher than research based on colder climates would indicate. However, if food production is insufficient, higher temperatures could be detrimental (NCRWQCB 2000).

The temperature criteria for coho salmon, steelhead, and Chinook salmon are presented in Table C-3. To assess project effects on salmonid habitat, the criteria scores were applied to temperature values predicted by the RRWQM (RMA 1995) for various flow regimes. The RRWQM predicts temperature and DO concentrations at nodes located along the Russian River and Dry Creek. Two daily periods are predicted, one at 6:00 a.m. and the other at 6:00 p.m. for each day from January 1, 1929 to September 30, 1995. The mean of these values is used to represent the average daily temperature and DO.

It is recognized that salmonids can withstand short-term exposure to temperatures higher than those required on average without significant negative effects. Because the ILT_{50} values reviewed in the literature and used in the evaluation criteria are based on a 96-hour exposure, an average score is calculated over a 4-day period using a model value for each 24-hour period.

Table C-3 Temperature Evaluation Criteria by Species and Life-History Stage

Coho Salmon

Score[1]	Nov 1 to Jan 31 Upmigration[2]		Dec 1 to Feb 15 Spawning		Dec 1 to Mar 31 Incubation		Oct 1 to Sept 30 Rearing	
0		≤ 3.0		≤ 1.7		≤ 0.0		≤ 1.7
1	> 3.0	≤ 4.0	> 1.7	≤ 3.0	> 0.0	≤ 3.0	> 1.7	≤ 4.0
2	> 4.0	≤ 5.0	> 3.0	≤ 4.0	> 3.0	≤ 3.5	> 4.0	≤ 7.0
3	> 5.0	≤ 6.0	> 4.0	≤ 6.0	> 3.5	≤ 4.0	> 7.0	≤ 8.0
4	> 6.0	< 7.2	> 6.0	< 7.0	> 4.0	< 4.4	> 8.0	< 12.0
5	≥ 7.2	≤ 12.7	≥ 7.0	≤ 13.0	≥ 4.4	≤ 13.3	≥ 12.0	≤ 14.0
4	> 12.7	≤ 14.0	> 13.0	≤ 14.0	> 13.3	≤ 14.0	> 14.0	≤ 15.0
3	> 14.0	≤ 15.0	> 14.0	≤ 15.0	> 14.0	≤ 15.0	> 15.0	≤ 16.0
2	> 15.0	≤ 16.0	> 15.0	≤ 16.0	> 15.0	≤ 16.0	> 16.0	≤ 20.0
1	> 16.0	< 21.1	> 16.0	< 17.0	> 16.0	< 18.0	> 20.0	< 26.0
0	≥ 21.1		≥ 17.0		≥ 18.0		≥ 26.0	

Steelhead

Score	Nov 1 to Jan 31 Upmigration		Dec 1 to Feb 15 Spawning		Dec 1 to Mar 31 Incubation		Oct 1 to Sept 30 Rearing	
0		≤ 4.0		≤ 4.0		≤ 1.5		≤ 0.0
1	> 4.0	≤ 5.0	> 4.0	≤ 5.0	> 1.5	≤ 3.0	> 0.0	≤ 2.0
2	> 5.0	≤ 6.0	> 5.0	≤ 6.0	> 3.0	≤ 4.5	> 2.0	≤ 4.0
3	> 6.0	≤ 7.0	> 6.0	≤ 7.0	> 4.5	≤ 6.0	> 4.0	≤ 8.0
4	> 7.0	< 7.8	> 7.0	< 7.8	> 6.0	< 7.8	> 8.0	< 12.8
5	≥ 7.8	≤ 11.0	≥ 7.8	≤ 11.1	≥ 7.8	≤ 11.1	≥ 12.8	≤ 15.6
4	> 11.0	≤ 13.0	> 11.1	≤ 14.0	> 11.1	≤ 13.0	> 15.6	≤ 18.0
3	> 13.0	≤ 15.0	> 14.0	≤ 16.0	> 13.0	≤ 15.0	> 18.0	≤ 20.0
2	> 15.0	≤ 17.0	> 16.0	≤ 18.0	> 15.0	≤ 17.0	> 20.0	≤ 23.9
1	> 17.0	< 21.1	> 18.0	< 20.0	> 17.0	< 20.0	> 23.9	< 26.0
0	≥ 21.1		≥ 20.0		≥ 20.0		≥ 26.0	

Chinook Salmon

Score	Nov 1 to Jan 31 Upmigration		Dec 1 to Feb 15 Spawning		Dec 1 to Mar 31 Incubation		Oct 1 to Sept 30 Rearing	
0		≤ 0.8		≤ 1.0		≤ 1.0		≤ 1.0
1	> 0.8	≤ 3.0	> 1.0	≤ 2.5	> 1.0	≤ 2.0	> 1.0	≤ 4.0
2	> 3.0	≤ 5.2	> 2.5	≤ 3.5	> 2.0	≤ 3.0	> 4.0	≤ 6.0
3	> 5.2	≤ 7.9	> 3.5	≤ 4.5	> 3.0	≤ 4.0	> 6.0	≤ 8.0
4	> 7.9	< 10.6	> 4.5	< 5.6	> 4.0	< 5.0	> 8.0	< 12.0
5	≥ 10.6	≤ 15.6	≥ 5.6	≤ 13.9	≥ 5.0	≤ 12.8	≥ 12.0	≤ 14.0
4	> 15.6	≤ 17.0	> 13.9	≤ 14.5	> 12.8	≤ 14.2	> 14.0	≤ 17.0
3	> 17.0	≤ 18.4	> 14.5	≤ 15.2	> 14.2	≤ 15.0	> 17.0	≤ 20.0
2	> 18.4	≤ 19.8	> 15.2	≤ 16.0	> 15.0	≤ 15.8	> 20.0	≤ 23.0
1	> 19.8	< 21.1	> 16.0	< 16.7	> 15.8	< 16.7	> 23.0	< 26.0
0	≥ 21.1		≥ 16.7		≥ 16.7		≥ 26.0	

[1] Low scores are associated with water temperatures that are too low and too high.
[2] Water temperature in °C.

References: Anonymous 1971; Bell 1986; Bjornn and Reiser 1991; Boles et al. 1988; Brett 1952; Brett et al. 1982; CDFG 1991; Resources Agency 1989; Cramer 1992; Fryer and Pilcher 1974; Hallock et al. 1970; Hanel 1971; McMahon 1983; Myrick and Cech 2000, 2002a, 2002b; Raleigh et al. 1984; Rich 1987; Seymour 1956; and EPA 1974.

C.1.3.1.2 Coho Salmon Temperature Requirements

Water temperature can affect upstream migration of coho salmon through direct mortality, increased susceptibility to disease, and delays in migration timing and maturation rates (Holt et al. 1975). Temperatures greater than 25.5°C are lethal to migrating adults (Bell 1973, cited in McMahon 1983), while prolonged exposure to sublethal temperatures can result in major prespawning mortality. Coho salmon are reported to migrate upstream at water temperatures between 7.2°C and 15.6°C (Bell 1991). However, as infection rates in coho salmon can increase dramatically above 12.7°C, spawning temperatures $\leq$ 13°C are recommended to minimize prespawning mortality (McMahon 1983). Based on these literature values, a score of 5 is assigned to water temperatures between 7.2ºC to 12.7ºC and a score of 4 for temperatures of 12.7ºC to 14.0ºC (Table C-3) (see Table A in Attachment 1). The score was decreased for every one degree increase in temperature, except for temperature range of 16°C to 21.1ºC which was assigned a score of 1. Temperatures greater than 21.1ºC are potentially sublethal and were assigned a score of 0 (McMahon 1983, using Hallock 1970 as an estimator). Scores for temperatures below 7.2ºC decline from 4 to 0 in one degree increments. Temperatures below 3.0ºC are assumed to severely affect migration.

Burner (1951, cited by McMahon 1983) observed coho salmon to spawn at temperatures between 2.8°C and 12.2°C. Temperatures in the range of 3°C to 7°C, however, are believed to slow maturation rates and thus reduce survival (Reingold 1968, in Bjornn and Reiser 1991). An EPA report (EPA 1974) for coho salmon on the Columbia River reported a preferred spawning temperature range of 7°C to 13°C, and that mortality rates increase when these threshold values are exceeded. Bell (1986) reports a narrower preferred range of 10°C to 12.8°C. Based on these literature values, a score of 5 (which represents optimal temperatures) is given to temperatures of 7.0°C to 13.0ºC during the spawning season (EPA 1974), and scores of 4 and 3 (which represent acceptable temperature ranges) to temperatures from 13.0°C to 15.0ºC (McMahon 1983). Scores of 1 and 0 are given to temperatures above 16ºC or below 3ºC (McMahon 1983, Bjornn and Reiser 1991).

Incubation temperatures for salmonid species affect embryo mortality, the time to embryo hatching and the physiology of emerging fry. Embryo viability is sensitive to high water temperature values, with elevated levels of mortality occurring when temperatures exceed 14°C (Reiser and Bjornn 1979). Survival rates of emerging fry increase as the duration of the incubation period decreases, which is inversely correlated with temperature (i.e., higher temperatures give rise to shorter incubation times).

Bell (1986) reports a preferred incubation water temperature of 10°C to 12.8°C, based on the length of incubation time and optimal growth rate of emerging fry. Stein et al. (1972) found that growth rates of coho salmon fry were highest for temperatures between 8.9°C and 12.8°C, but growth rates decreased at 18.1°C. Bjornn and Reiser (1991) suggest the optimal water temperatures for coho salmon incubation have a larger range of 4.4°C to 13.4ºC and that embryo survival only decreases once these values are exceeded. McMahon (1983) reports that coho salmon stop growing altogether at temperatures above

20.3°C, and mortality rates increase as a function of temperature above 12°C. Based on these literature values, a score of 5 is assigned to temperatures between 4.4°C to 13.3ºC during the incubation period (Bjornn and Reiser 1991, Bell 1986). Scores of 4 and 3 are given to water temperatures between 13.3°C to 15.0ºC, and scores of 2 and 1 to temperatures between 15.0°C to 18.0ºC (McMahon 1983). A score of 0 is given to temperatures above 18.0ºC, representing an unacceptable level of mortality. Scores for temperatures below 4.4ºC decrease by one unit for every 0.5ºC decrease in temperature. Water temperatures less than 3°C represent the lower lethal limit for embryo survival and are given a score of 1.

Juvenile coho salmon rear at temperatures between 3.3°C and 20.6°C (Bell 1991). Brett (1952) experimentally determined a lower ILT for coho salmon of 0.8ºC and an upper ILT of 26.2ºC. Preferred water temperatures are reported to range from 11.7°C to 14.4°C (Bell 1991), and 12°C to 14°C (Brett 1952). Growth of juveniles is slowed at low temperatures due to a reduction in metabolic processes and at high temperatures because the amount of food required for physiological maintenance increases (Bjornn and Reiser 1991). Based on these literature values, a score of 5 is given to temperatures between 12.0°C to 14.0ºC for the coho salmon rearing period (Bjornn and Reiser 1991, Brett 1952). Scores of 4 and 3 are given to temperatures between 14.0°C and 16.0ºC (McMahon 1983) and scores of 2 and 1 to temperatures from 16.0°C to 26.0ºC, representing temperatures that stress rearing fish. A score of 0 is given to temperatures above 26.0ºC, representing temperatures that reduce growth or kill fish. Temperatures below 12ºC are assigned scores from 4 to 0 in accordance with the function relationship developed by McMahon (1983) for overwintering smolts.

C.1.3.1.3 Steelhead Temperature Requirements

Delays in steelhead migration occur when natal streams are too warm (Major and Mighell 1966). Bjornn and Reiser (1991) report that upstream migrants prefer temperatures in the range of 10°C to 13ºC, while a CDFG report (1991) on Mokelumne River steelhead gives a preferred range of 7.8°C to 11.0ºC. Upstream migrating can stop altogether when temperatures reach 21.1ºC (Beschta et al. 1987, Cramer 1992) or falls below 4.0ºC. Based on these literature values, a score of 5 is given to temperatures of 7.8°C to 11.0ºC. A score of 0 is given to temperatures above 21.1ºC and below 4.0ºC, as these represent temperatures at which migration potentially ceases. The remaining temperature range is scored from 4 to 1 by interpolation between preferred and migration-inhibiting temperature values.

Successful spawning of steelhead is affected by water temperature before, during, and after spawning. Bell (1986) reports the preferred temperature range for Columbia River steelhead during spawning is 3.9ºC to 9.4ºC. A CDFG report (1991) for the American River reports a somewhat higher preferred range of 7.8ºC to 11.1ºC, which includes the effects of temperature on embryo survival. Raleigh et al. (1984) reports that brood steelhead should remain in water temperatures below 14.0ºC for 2 to 6 months before spawning, to ensure the production of good quality eggs. He also found that temperatures above 20.0ºC are unsuitable for spawning success. Based on the American River findings, a score of 5 is given to temperatures between 7.8ºC to 11.1ºC. A score of 4 is given to temperatures between 11.1ºC and 14.0ºC, as this is the temperature at which embryo quality declines (Raleigh et al. 1984). A score of 0 is given to temperatures above 20.0ºC and below 4.0ºC while the remaining scores are estimated by interpolation.

The preferred incubation temperatures for steelhead mirrors those for spawning, since the best scientific information available is the embryo survival data from the American River (CDFG 1991). Therefore, a score of 5 is given to temperatures between 7.8ºC to 11.1ºC. Since a temperature of 20.0ºC is unsuitable for spawning (Raleigh et al. 1984), it is given a score of 0. The lower temperature limit on embryo survival for steelhead is 1.5ºC (Raleigh et al. 1984), which is also given a score of 0. The remaining incubation scores are estimated by interpolation.

The preferred water temperatures for rearing juvenile steelhead on the American River are reported to range from 12.8°C to 15.6ºC (CDFG 1991), while Bell (1986) reports a somewhat lower preferred range of 10°C to 12.8ºC for steelhead in the Pacific Northwest. The experimentally established lower and upper ILT for steelhead are 0.0ºC and 23.9°C, respectively (Bell 1986, Bjornn and Reiser 1991). Hatchery-reared Central Valley steelhead consistently selected temperatures of 18 to 19°C, while wild fish, which were probably exposed to cooler temperatures in the Feather River, selected temperatures of about 17°C (Myrick and Cech 2000).

Temperature tolerances of steelhead in the southern portion of their range have not been well-documented and may be higher. In the Eel River, juvenile steelhead were observed feeding in surface waters with ambient temperatures up to 24.0°C (Nielsen et al. 1994). Roelofs et al. (1993) classified water temperatures in the Eel River as extremely stressful for steelhead above 26.0°C. Roelofs et al. (1993) report temperatures between 23.0°C and 26.0°C as causing chronic physiological stress that jeopardizes survival, and temperatures between 20.0°C and 23.0°C as producing chronic effects. A maximum weekly average temperature (MWAT) of 19ºC was calculated for steelhead by EPA (Brungs and Jones 1977, cited in Sullivan et al. 2000).

Steelhead use behavioral thermoregulation to survive stressful thermal conditions. For example, fish in streams and rivers utilize temperature gradients, such as thermal stratification in deep pools (Nielsen et al. 1994, Matthews et al. 1994).

Increases in water temperature will increase standard metabolism and food demand of salmonids. This demand can be met, up to a point, through higher water velocities, which can provide large amounts of drifting invertebrate food. Smith and Li (1982) reported that in Uvas Creek (Pajaro River watershed), steelhead eat more and maintain higher growths during high-flow regimes. By utilizing higher water velocity, and shallower and coarser substrate microhabitat, steelhead take advantage of portions of the water column substantially faster and more productively than at their resting positions. The fish make extensive use of cover to avoid higher water velocities and keep metabolic demand low, but use adjacent areas of sheer or “feeding lanes” to harvest drifting food.
Thus, steelhead eat more and maintain higher growth rates than they would in areas of slower velocity. Smith (1982) found that the density of trout in warmer stream reaches (19°C to 23ºC) was strongly dependent on water velocity, while in cooler stream reaches

(13°C to 17ºC), trout density was independent of water velocity. Warmer water temperatures will generally result in better growth at unlimited food up to a point, above which growth declines or fish lose weight.

Myrick and Cech (2000) investigated the effects of water temperature (10°C to 25ºC) on juvenile rainbow trout of the Eagle Lake subspecies and the Mt. Shasta strain to investigate the responses of different genetic strains to temperatures. No strain-related differences were found in conversion efficiency, oxygen consumption rates, thermal tolerance or swimming performance, but the Mt. Shasta strain trout grew faster at the highest temperatures (22 to 25ºC). Growth rates increased with temperature to a maximum near 19°C and declined at higher temperatures. Both strains were able to maintain weight at 25ºC for 30 days, which the authors suggest may allow them to survive short (<1 month) periods of sublethal temperatures in California streams.

Sullivan et al. (2000) completed a review of the effects of temperature on salmonids in the Pacific Northwest. They caution that careful consideration must be given to magnitude and duration of temperatures, and utilize a risk assessment approach to quantitatively estimate acute and chronic effect of temperature on salmonids. Their analysis suggested that there is little or no risk of mortality if annual 7-day maximum temperature is less than 26°C, but nevertheless suggest site-specific analyses be conducted when annual 7-day maximum temperature exceeds 24°C in local river conditions. Assuming an acceptable growth loss of 10 percent is an appropriate risk level, they suggest an upper threshold for the 7-day maximum temperature of 20.5°C is appropriate.

The NCRWQCB reviewed the water quality objective for temperature in the Russian River basin in Sonoma County to protect aquatic life, including listed species (NCRWQCB 2000). The review concludes that the upper lethal temperature for young steelhead is around 75º (23.9ºC), and that a maximum 7-day average stream temperature of 64ºF (17.8ºC) and a daily maximum temperature of 75ºF (23.9ºC) in the Russian River would likely protect the salmonid species present (including coho and Chinook salmonids). The report identified alternatives for the revision of the water quality objective for temperature, which are undergoing further review. The NCRWQCB report cautions that one of the difficult components to quantify is the effect of food availability on temperature tolerances of rearing salmonids, particularly for steelhead, as discussed in Smith and Li (1983). If primary and secondary production is high, then a numeric temperature objective specific to steelhead in the southern portion of their range may be higher than research based on colder climates would indicate. However, if food production is insufficient, higher temperatures could be detrimental (NCRWQCB 2000).

Myrick and Cech (2001) reviewed temperature effects on Central Valley steelhead. Located close to their southernmost range, Central Valley steelhead studies provide relevant information for the Russian River. Steelhead can be expected to show significant mortality at chronic temperatures exceeding 25ºC, although they tolerate temperatures as high as 29.6ºC for short periods of time. However, they experience sub-lethal effects at temperatures below these limits. Steelhead/rainbow trout acclimated to high temperatures tend to show greater heat tolerance than those acclimated to cooler temperatures (Cherry et al. 1977, Myrick 1998). Wild fish in thermal gradients selected temperatures around 17ºC, although the authors note that temperatures selected by Great Lakes rainbow trout increased with acclimation temperature from about 15ºC to 20º. Juvenile steelhead grow at temperatures ≤6.9°C to at least 22.5°C. The highest growth rates reported for Central Valley steelhead occurred at 19°C (Cech and Myrick 1999), but higher temperatures have not been tested. The ability of salmonids to tolerate elevated temperatures is a function of exposure time. The authors suggest that there may be physiological differences between California steelhead and those from more northern latitudes that result in different growth rates, but indicate that large-scale experiments are needed to draw clear conclusions.

As the Russian River watershed lies in the southern and warmer range of salmonid species, temperature criteria based on published values in colder climates would be conservative. Temperature criteria based on values from the American River are more likely to represent Russian River steelhead. A score of 5 is assigned to temperatures ranging from 12.8°C to 15.6ºC. A score of 0 is assigned to the experimentally derived lower and upper ILT values (Bell 1986, Bjornn and Reiser 1991), and remaining scores are estimated by interpolation. However, steelhead in the southern portion of their range may have higher temperature tolerances than studies in the Pacific Northwest suggest; therefore, these criteria may be conservative.

C.1.3.1.4 Chinook Salmon Temperature Requirements

McCullough (1999) found that migrating adult Chinook salmon die at temperatures of 21°C to 22ºC in the Columbia River. Observations in the San Joaquin River indicate that upstream migration is halted when temperatures exceed 21.1ºC (Hallock 1970, Cramer 1992). However, upstream migration of adult salmon has been noted in the lower Klamath at water temperatures as high as 24.4°C (Dunham 1968, cited in Boles 1988). Chinook salmon have been observed migrating upstream in the Russian River on days with a daily average temperature over 22.6°C (Chase et al. 2003). At the lower end of the temperature scale, Chinook salmon have been reported to migrate upstream in water temperatures as low as 3ºC (Bell 1986). Preferred upstream migration temperatures reported for summer-run Chinook salmon range from 13.9ºC to 20ºC, and for fall-run Chinook salmon range from 10.6ºC to 19.4ºC (Bell 1986). The Independent Scientific Group (1996), however, found that metabolic stress for migrating Chinook salmon increases when temperatures are greater than 15.6ºC, suggesting that preferred temperatures are lower than originally reported by Bell (1986). Based on these literature values, a score of 5 is assigned for water temperatures between 10.6°C to 15.6ºC. A score of 0 is assigned to temperatures greater than 21.1ºC, representing temperatures that published criteria suggest are lethal to migrating adults (Hallock 1970, Cramer 1992, Independent Science Group 1996). However, Chinook salmon in the southern portion of their range, including the Russian River (Chase et al 2003) may have higher temperature tolerances than studies conducted in the Pacific Northwest suggest. Criteria scores for temperatures between 15.6°C and 21.1ºC, and between 10.6°C and 0.8ºC, are estimated by interpolation.

While Chinook salmon can spawn in water temperatures ranging from 1ºC to 20ºC (Seymour 1956, Bell 1986), their preferred temperature range is much narrower (Bjornn and Reiser 1991). In British Columbia, Shepherd et al. (1986) observed that Chinook salmon adults typically spawn at temperatures between 10ºC to 17ºC. In the American River, Bell (1986) reports a lower preferred spawning range temperature of 5.6°C to 13.9ºC. Boles et al. (1988) found that embryo mortality of Sacramento River Chinook salmon increased dramatically when temperatures climbed above 16.7ºC and considers this temperature an upper limit for successful spawning. Based on findings in the American River, a score of 5 is assigned to temperatures between 5.6ºC to 13.9ºC. A score of 0 is assigned to temperatures above 16.7ºC (Boles et al. 1988) and below 1.0ºC (Seymour 1956, Bell 1986). The remaining scores were estimated by interpolation following the functional temperature relationships derived by McMahon (1983) for the Chinook salmon habitat suitability index model.

Optimal temperatures for incubation of Chinook salmon embryos depend on the water temperature adults are exposed to prior to spawning (Hinze 1959). Given these constraints, however, preferred incubation temperatures are thought to range from 4.4ºC to 13.3ºC (Bjornn and Reiser 1991) and 5.0ºC to 12.8ºC (Seymour 1956, Boles et al. 1988). Mortality rates for emerging fry increase by 20 percent when temperatures rise from 12.8ºC to 15.6ºC, and by at least 30 percent when temperatures reach 16ºC (Resource Agency Report 1989). Temperatures greater than 16.7ºC have been found to cause 100 percent mortality of Chinook salmon fry in the Sacramento River (Boles et al. 1988, Resource Agency Report 1989). A score of 5 was assigned to the preferred temperature reported by Seymour (1956) and Boles et al. (1988), as these are below the temperature values at which mortality rates of emerging fry increase. Scores of 4 and 3 are given for temperatures between 12.8ºC and 15.0ºC (Resource Agency Report 1989) and 2 and 1 for temperatures between 15.0ºC and 16.7ºC (Boles et al. 1988). Temperatures above 16.7ºC and below 1.0ºC are given scores of 0 (Boles et al. 1988, Resource Agency Report 1989, Raleigh et al. 1986). Criteria scores for temperatures between 5.0ºC and 1.0ºC are estimated by interpolation.

The upper and lower ILT during rearing of Chinook salmon juveniles have been determined experimentally. Brett (1952) estimated these values to be 0.8ºC and 26.2ºC, respectively, with spring-run Chinook salmon. He also reports a preferred rearing temperature range of 12ºC to 14ºC. Myrick and Cech (2002b) found that American River fall-run Chinook salmon, when fed at satiation rations, food consumption and growth rates increased as temperature increased over an 11 to 19°C range, but with insufficient food, juvenile salmon were not capable of maintaining condition over that range. Juvenile Chinook salmon showed positive growth at temperatures as high as 25°C (Brett et al. 1982, cited in Myrick and Cech 2001). A score of 5 is given to the preferred rearing temperatures (Brett 1952), while a score of 0 is assigned to lower and upper ILT values. The remaining rearing scores are estimated by interpolation.

C.1.3.2 Dissolved Oxygen

DO requirements vary with species, age, temperature, water velocity, activity level, and concentration of substances in the water (McKee and Wolf 1963, cited in Raleigh et al. 1984). As temperatures increase, DO saturation levels in the water decrease while the oxygen needs of the fish increase. Optimal oxygen levels for rainbow trout (the nonanadromous form of steelhead) appear to be ≥7 milligrams per liter (mg/l) at <15°C and ≥9 mg/l at >15°C (Raleigh et al. 1984). Incipient lethal levels of DO for adult and juvenile rainbow trout are approximately 3 mg/l, depending primarily on temperature.

Reduced concentrations of DO can reduce the swimming performance of migrating adult salmonids. Maximum sustained swimming speeds of juvenile and adult coho salmon at temperatures between 10°C to 20°C were reduced when DO dropped below air-saturated levels (approximately 8 to 9 mg/l at 20°C), and performance declined sharply when DO fell to 6.5 to 7.0 mg/l at all temperatures (Davis et al. 1963).

For embryos, the amount of oxygen available is influenced by flow through redds. Embryos are most sensitive to hypoxial conditions during their early stages of development (Alderdice et al. 1958, cited in Bjornn and Reiser 1991). While embryos may survive when DO concentrations are below saturation (but above a critical level), their development is often abnormal. Newly hatched steelhead and Chinook salmon alevins (yolk sac fry that hatch from the eggs and live for a brief period within the interstitial spaces of the streambed gravels) were smaller and weaker when incubated as embryos at low and intermediate DO concentrations than at higher concentrations (Silver et al. 1963). Reduced DO lengthened the incubation period of coho salmon embryos and they hatched as smaller alevins (Shumway et al. 1964, cited in Bjornn and Reiser 1991). In field studies, survival of steelhead (Coble 1961) and coho salmon embryos (Phillips and Campbell 1961) was positively correlated with intragravel DO in redds. Phillips and Campbell (1961) concluded that intragravel DO must average 8 mg/l for embryos and alevins to survive well. Bjornn and Reiser (1991) recommend that concentrations should be at or near saturation and that temporary reductions should drop no lower than 5.0 mg/l. The USFWS (Raleigh et al. 1986) recommends that for Chinook salmon, the lower limit of DO for survival with short-term exposures is ≥ 2.5 mg/l at temperatures ≤ 7°C; with optimal levels of ≥ 8 mg/l at temperatures between ≥ 7°C and ≤ 10°C, and ≥ 12 mg/l at temperatures >10°C.

Growth rate and food conversion efficiency in coho salmon juveniles are limited by DO concentrations less than 5 mg/l (Bjornn and Reiser 1991). Davis (1975) reviewed information on incipient DO response thresholds and has developed oxygen criteria related to concentration, water temperature, and percent saturation. Davis concluded that salmonids would not be impaired at concentrations near 8 mg/l (76 to 93 percent saturation) and that initial symptoms of DO deprivation would occur at approximately 6 mg/l (57 to 72 percent) saturation (Bjornn and Reiser 1991) (Table C-4). Because rainbow trout fry occupy habitat contiguous with adults, their DO requirements are assumed to be the same as adults (Raleigh et al. 1984). Bustard (1983, cited in Raleigh et al. 1986), reported that Chinook salmon juveniles survived with DO ranging from 3 to 7 mg/l. The USFWS has concluded that Chinook salmon juveniles can survive short-term exposures to 3 mg/l at temperatures ≤ 5°C, but optimal levels are ≥ 9 mg/l at ≤ 10°C and 13 mg/l at > 10°C.

Table C-4 Response of Freshwater Salmonid Populations to Three Concentrations of DO (Bjornn and Reiser 1991, Modified from Davis 1975)

Response	DO (mg/l)	Percent Saturation at Temperature (°C)					
		0	5	10	15	20	25
Function without impairment	7.75	76	76	76	76	85	93
Initial distress symptoms	6.00	57	57	57	59	65	72
Most fish affected by lack of oxygen	4.25	38	38	38	42	46	51

Criteria for DO are given in Table C-5. They are based on the literature cited and on the habitat suitability index models developed by USFWS.

Table C-5 DO Evaluation Criteria by Species and Life-History Stage

Coho Salmon				
	Nov 1 to Jan 31	Dec 1 to Mar 31	All Year	Feb 1 to May 15
Habitat Score	DO (mg/l) Upmigration	DO (mg/l) Spawning/ Incubation	DO (mg/l) Rearing	DO (mg/l) Downmigration
5	6.5	11.0	8.0	8.0
4	6.0	9.5	6.5	6.0
3	5.5	8.0	6.0	5.5
2	5.2	7.5	5.2	5.2
1	4.8	4.5	4.5	4.6
0	< 4.8	< 4.5	3.0	3.0
Steelhead				
	Jan 1 to Mar 31	Jan 1 to May 31	All Year	Mar 1 to Jun 30
Habitat Score	DO (mg/l) Upmigration	DO (mg/l) Spawning/ Incubation	DO (mg/l) Rearing	DO (mg/l) Downmigration (Juveniles)
5	6.5	9.0	8.0	8.0
4	6.0	7.3	6.5	6.0
3	5.5	6.5	6.0	5.5
2	5.2	5.9	5.2	5.2
1	4.8	5.4	4.5	4.6
0	< 4.8	< 5.0	3.0	3.0

Table C-5 DO Evaluation Criteria by Species and Life-History Stage (Continued)

Chinook Salmon

Habitat Score	Aug 15 to Jan 15 DO (mg/l) Upmigration	Nov 1 to Mar 31 DO (mg/l) Spawning/ Incubation	Feb 1 to Jun 30 DO (mg/l) Rearing	Feb 1 to Jun 30 DO (mg/l) Downmigration
5	6.5	11	8.0	8.0
4	6.0	9.5	6.5	6.0
3	5.5	8	6.0	5.5
2	5.2	7.5	5.2	5.2
1	4.8	4.5	4.5	4.6
0	< 4.8	< 4.5	3.0	3.0

C.1.3.3 TURBIDITY

An increase in sediment input and turbidity in a stream can create physiological or behavioral responses in salmonids. Sediment input can affect the survival of eggs. Turbidity reduces the amount of light that can penetrate water. Turbidity may affect salmonids indirectly by reducing primary productivity in a stream, which, in turn, affects the food web.

Although the terms "turbidity" and "suspended solids" are sometimes used interchangeably, the degree of turbidity does not always indicate the amount of particulate matter in the water. Turbidity is measured by the amount of light that penetrates the water and is measured in nephelometric turbidity units (NTUs) or Jackson turbidity units (JTUs). It is not a measure of the quantity or type of suspended matter, and similar concentrations of different types of suspended matter could result in different turbidity readings. An increase in suspended solids can be caused by increased sediment loading and sediment load can be measured in mg/l. Suspended sediment concentrations are more difficult to measure than turbidity. Equations have been developed to estimate suspended sediment concentrations from turbidity measurements, but researchers caution that relationships differ between drainages due to specific sediment characteristics (Lloyd et al. 1987).

In most streams, water is naturally turbid at times, usually when storms produce runoff. In fact, moderate levels of turbidity may give juveniles protection from predators. Turbidity levels of approximately 23 NTU apparently reduced the perceived risk of predation on juvenile Chinook salmon (Gregory 1993). Chinook salmon occupy turbid rivers for a significant portion of their early life.

High suspended-solid concentrations cause physiological and behavioral stress responses (Newcombe and MacDonald 1991), but lower concentrations may reduce predation on juveniles. Low or moderate exposures of short duration can be tolerated by the fish. In general, however, salmonids survive better in clear water at all lifestages, and high, long-term levels of turbidity can negatively affect them (Newcombe and Jensen 1996).

Newcombe and Jensen (1996) analyzed data from 80 studies on fish responses to suspended sediment in streams and estuaries. Categories of effects ranged from "no effect" to "behavioral and sublethal effects" to "lethal effects." Turbidity effects can range from behavioral effects like alarm reactions or avoidance responses to lethal and paralethal effects like reduced growth, delayed hatching, and mortality. In between these extremes are sublethal effects such as reduction in feeding, physiological stress, and poor condition.

Migrating salmonids avoid water with very high silt loads and will cease migration (Cordone and Kelley 1961, cited in Bjornn and Reiser 1991). However, they can migrate with high turbidity levels often associated with rainfall events.

Suspended sediment effects on eggs are not as clearly defined in terms of suspended solids as much as by the percent of fines in the gravels. When an excess of silt is deposited after spawning, intergravel flow is reduced and eggs can be "smothered". This results in a loss of DO, accumulation of catabolic waste products, and the promotion of fungal growth. Generally, 85 percent of salmon eggs will die if 15 to 20 percent of the voids are filled with sediment (Bell 1991).

Newly emerged fry are more susceptible to moderate turbidities than older fish (Bjornn and Reiser 1991). Turbidities in the 25 to 50 NTU range (equivalent to 125 to 275 mg/l of bentonite clay) reduced growth and caused more young coho salmon and steelhead to emigrate from laboratory streams than did clear water (Sigler et al. 1984). Larger juveniles and adults do not appear to be affected by ephemerally high concentrations of suspended sediments like those that occur during storms. However, juvenile coho salmon avoided water with turbidities exceeding 70 NTU (Bisson and Bilby 1982). Feeding and territorial behavior of juvenile coho salmon were disrupted by short-term exposures (2.5 days to 4.5 days) to turbid water (up to 60 NTU) (Berg and Northcote 1985). Juvenile salmonids tend to avoid chronically turbid streams (Lloyd et al. 1987) except when they use them as migration routes. Young salmonids subjected to continuous clay turbidities had lower growth rates than those living in clear water (Sigler et al. 1984).

Chronic turbidity decreases light penetration in streams, which can reduce primary productivity. Dramatic changes in light penetration and primary production can be caused by even small (5 to 10 NTUs) increases in turbidity above naturally clear conditions (Lloyd et al. 1987). By modeling the effect of various turbidity levels on light available at depth, Lloyd et al. (1987) calculated that a turbidity of only 5 NTUs can decrease the primary productivity of shallow, clear-water streams in Alaska by approximately 3 to 13 percent. An increase of 25 NTUs may decrease primary production by 13 to 50 percent. This can result in decreased production of zooplankton and macroinvertebrates (secondary production), and decreased abundance and production of fish (Lloyd et al. 1987). Lloyd, therefore, suggests a moderate level of protection for salmonids would be 25 NTUs above natural conditions in streams. A higher level of protection would be 5 NTUs above natural conditions, which would bring total turbidities in salmonid streams to 8 NTUs. Absolute turbidities of 8 NTUs and higher have been shown to reduce sport fishing in Alaska.

The Water Quality Control Plan for the North Coast Region sets a standard for turbidity as

> *"Turbidity shall not be increased more than 20 percent above natural occurring background levels. Allowable zones of dilution within which higher percentages can be tolerated may be defined for specific discharges upon the issuance of discharge permits or waiver thereof."*

The standard for suspended material is

> *"Waters shall not contain suspended material in concentrations that causes nuisance or adversely affect beneficial uses."*

It is difficult to determine what naturally occurring background levels are. The sediment criteria are not specific enough to protect salmonid habitats from the cumulative effect of sediment-related effects. Therefore, the NCRWQCB may propose numeric instream targets to integrate cumulative effects over annual timeframes instead of indicators that measure instantaneous conditions. The targets would be expressed as 10-year rolling average values (NCRWQCB 2000). The criteria proposed here are designed to be more specific than current NCRWQCB standards.

Criteria are developed for turbidity measured in NTUs for rearing and spawning habitat (Table C-6). A conversion ratio for NTUs to mg/l suspended solids may give only a rough estimate of suspended-solid concentrations in this watershed. It should be kept in mind that short exposures (a few hours to a couple of days) would have less of an effect than long exposures (a week or more). However, even short exposures of high turbidity (greater than 70 NTUs) can have severe effects.

For migration corridors, a less stringent set of turbidity criteria was developed. Since turbidity and suspended solids are thought to protect juveniles from predators, criteria for downstream migration have relaxed turbidity standards, up to the point that physiological stress is not excessive.

Table C-6 Evaluation Criteria for Turbidity

Score	Rearing Turbidity (NTU)	Juvenile Migration Turbidity (NTU)
5	< 10	< 25
4	10 – 15	25 – 50
3	15 – 25	50 – 60
2	25 – 50[1]	60 – 65
1	50 – 70[2]	65 – 70
0	> 70[3]	> 70

References:
1 Sigler et al. 1984
2 Berg and Northcote 1985
3 Bisson and Bilby 1982

C.1.4 Fish Passage Criteria

Evaluation criteria are presented for fish passage at fish passage structures (fish ladders or restoration actions that improve fish passage) and for fish passage past diversion facilities.

C.1.4.1 Fish Passage Structures

Fish passage structures are usually required when anthropogenic structures such as culverts or dams block spawning runs. Deleterious effects on salmonids can occur during construction, operation, and maintenance of fish passage structures. These structures also have the potential to increase predation on protected species by concentrating predators (including fish, birds, and humans) and prey. Evaluation criteria for predation are presented in the next section.

Effects on fish passage may not have been considered during culvert design or installation. High-velocity water flows can severely restrict the upstream passage of fish, while low flows decrease water depth, thereby preventing upstream and/or downstream migration. For fish to swim through a culvert, a flow depth no less than the body width of the maximum-sized fish is required (Bell 1990). The length and slope of the culvert, combined with site-specific water velocities, also affect the ability of fish to swim upstream. Erosion at the outflow of the culvert can create a drop that blocks access to its entrance. If a splash apron is constructed to reduce erosion, it may also become a barrier to passage.

Dams may restrict fish passage in several ways. One way is to block passage directly. Another is to change the channel in such a way as to restrict fish migration. For example, Mumford Dam caused downcutting below its base to the point where upstream passage for anadromous fish was difficult or impossible over most flow conditions.

C.1.4.1.1 Evaluation Criteria for Fish Passage Design

Successful fish passage depends on several factors, including the species type, the developmental stage, the fishway entrance design, the style of fish passage used, and the rate of flow in the fishway. To ensure successful fish passage, the fishway must be carefully engineered in terms of width and depth relationships to provide the required low velocity flows. The design must also make it easy for fish to find the entrance with minimal or no delay. Finally, there must be enough water flowing through the fishway so that fish can find the entrance to the structure (attraction flow) and pass upstream with minimal delays.

While there are several types of designs, most fish passages contain some common design features. These features are summarized below (Bell 1990) and serve as a guideline for assessing design and operational issues. It should be noted that some of these features may not apply to fish passage designed to mimic natural conditions within a creek.

- Resting area velocities: 0.1 foot per second in pools, or a tenth of the normal swimming speed;
- *(either)* Maximum drop: 12 inches between pools;
- *(or)* Average maximum velocities over weirs or through orifices: 8 feet per second (fps);
- Entrance velocities into passage: 4 to 8 fps;
- Travel time through fishway: 2.5 to 4 minutes per pool;
- Space for fish in pool: 0.2 cubic foot per pound of fish; and
- Entrance eddies: recommended that cross-velocity not exceed 2 fps at 0 fishway discharge.

Achieving favorable attraction conditions is a function of such factors as fish behavior, river size, fishway flow strength, location of fishway entrance, and flexibility of the spillway operation. As river flows change, the relative importance of each component changes.

Site-specific conditions, especially tailwater hydraulics and channel width, determine entrance flow requirements. Fish will migrate along the channel banks during high flows to take advantage of lower flow velocities. Migrating fish will search laterally in combination with short fallbacks when confronted by a barrier. Low-flow entrances can be located close to the base of dams and should also be located beneath the nappe of the spillway when it separates a substantial distance from the dam. The location of the entrance should be at the upstream-most point of fish passage, and the location must take into account the locations where fish hold before attempting to pass the barrier. The entrance flow should be high enough to compete with spillway flow for fish attraction.

The jet of water leaving the fishway entrance is an extension of the fishway into the tailwater and it guides fish to the entrance. The greater the momentum of the jet, the further it reaches into the tailwater and the more successfully it can guide fish to the entrance. When a low-flow entrance is aligned perpendicular to the channel alignment, parallel to the barrier, or oriented at a small angle, the entrance jet penetrates the tailwater to a greater extent than if aligned perpendicular to the flow in the tailrace. When a high-flow entrance is placed at a low angle (30-degree angle), the protrusion into the stream of an angled entrance provides an abutment and velocity shadow behind which fish move upstream, and then passage is blocked by the abutment and high water velocities upstream of the entrance.

Attracting migrants to fish passages is particularly important during adult spawning runs when river flows are usually high. Insufficient attraction flows could make it difficult for adult fish to find the entrance to the fishway, thereby creating migration delays. In general, an attraction flow through the fishway system of 10 percent or more of the total streamflow is sufficient to guide fish. However, this 10 percent criterion can be impractical at very high flows, and therefore other fishway design factors (discussed above) can be considered. Because most of the streamflow passes through the fishways evaluated for this BA, except during very high flows (storm events), evaluation criteria are not needed. Evaluation criteria for adult fish passage are presented for fish ladder design and operation.

Adult spawning migrations are induced by freshets. The fish passage structure should operate effectively at a range of flows that is wide enough to prevent substantial migration delays. Several design flow criteria have been developed. Gebhards and Fisher (1972, cited in Bates 2000) suggests migration delays should not exceed 6 consecutive days. Dryden (1975, cited in Bates 2000) recommends that a 7-day migration delay should not be exceeded more than once in 50 years and a 3-day migration delay should not be exceeded during the average annual flood. CDFG suggests that passage should be provided during at least 90 percent of the flows that will be encountered for the target species during its migration period (Bates 1988).

Table C-7 lists scoring categories for the effectiveness of a fish passage design. High scores are given to fish passage facilities that meet the basic design criteria described above and pass fish with minimal or no delay.

Table C-7 Adult Fish Passage Evaluation Criteria Based on Fish Ladder Design and Operation

Category Score	Evaluation Categories
5	Fish passage passes adult salmonids without delay.
4	Fish passage passes adult salmonids with acceptable delay.
3	Fish passage passes all target species after extended delay.
2	Fish passage does not pass all target species of adult salmonids.
1	Passage provided but does not appear to pass any adult salmonids, or passage not provided.

Most published criteria address upstream spawning migrations, but juvenile downstream passage is also required. Juvenile downstream migrants have a finite amount of time to complete the physiological change (smoltification) that enables them to survive in a marine environment. A substantial delay in migration may result in smolts reverting to a resident form and they may spend an additional year in fresh water. Downstream migrant smolts need a minimum of 6 inches depth of water (Flosi et al. 1998). Furthermore, if a barrier decreases water velocity upstream, downstream passage through the fishway may be delayed or impeded entirely.

Restoration and conservation actions designed to restore fish passage may utilize design elements that improve both upstream and downstream passage for all life-history stages of salmonids, as well as for other species. They are likely to restore some of the natural functions inherent in an interconnected riverine ecosystem. Fish passage projects that restore the geomorphology of the stream are likely to have a greater benefit than a fishway that is designed primarily to pass adult salmonids. A fish passage project that removes a passage impediment or restores the geomorphology of a stream channel in a way that reestablishes good fish passage conditions would be beneficial to protected fish species.

C.1.4.2 Fish Passage Past Diversion Facilities

Death or injury of juvenile salmonids at water diversion intakes has been identified as a major source of fish mortality (National Marine Fisheries Service [NMFS] [now known as NOAA Fisheries] 1994). Improperly designed diversion facilities can cause impingement or entrapment of individuals and delay migration, and can result in stress-related injury or death.

When water in the infiltration ponds and flood control reservoirs becomes shallow and and/or stagnant, the likelihood of stress-related injuries to juveniles increases. There is also an increased potential for physical injury during fish rescue operations. In addition, if water levels drop too low, the flat bottom of a pond can cause stranding. Finally, if there is little cover in the ponds or reservoirs, predation rates of juveniles by predatory fish and avian species increase with decreasing water levels, and entrapped adults may be at a higher risk from poachers.

Evaluation criteria for fish passage at a diversion facility are based on 1) the proportion of surface water diverted, and/or 2) the degree of overlap between the migration period and the period of diversion operation.

In general, if more water is diverted during juvenile migration, the potential to affect fish increases. Chinook salmon and steelhead smolt tend to migrate downstream with rising flows, in addition to other factors (Mundy 1997). Their tendency is to move away from river margins (i.e., rearing habitat) and into mid- to near-surface water with increasing flow (McDonald 1960, cited in Northcote 1984), which may decrease their risk for entrainment or injury. It is estimated that if more than 50 percent of surface water flow is diverted, there is a significant risk of entrapment for salmonids. A score of 5 is given to facilities that do not affect surface flow during the migration period. A score of 1 is given to facilities that divert more than 75 percent of the surface water (Table C-8).

Table C-8 Juvenile Passage Evaluation Criteria — Opportunity for Entrapment, Impingement, or Injury During Operation — Amount of Water Diverted

Category Score	Evaluation Category
5	Facility does not affect any surface flow.
4	Facility diverts less than 25% of surface water flow.
3	Facility diverts between 25% to 50% of surface water flow.
2	Facility diverts between 50% to 75% of surface water flow.
1	Facility diverts more than 75% of surface water flow.

The effect of diversion timing on juvenile salmonid migration is evaluated by assessing the degree of overlap between the migration period and project operations. A score of 5 is given to facilities that do not affect surface water flow during any of the migration period, while a score of 1 is given to facilities that affect surface flows more than 25 percent of the time (Table C-9).

A diversion structure is often equipped with fish screens to prevent entrainment of young salmonids in diverted water. The effectiveness of these screens is evaluated to determine if salmonid juveniles or fry can pass the diversion without injury or delay.

Table C-9 Juvenile Passage Evaluation Criteria — Opportunity for Entrapment, Impingement, or Injury — Time Water is Diverted

Category Score	Evaluation Category
5	Facility does not affect surface water flow during any time of migration period.
4	Facility diverts surface water flow during less than 10% of migration period.
3	Facility operates between 10% and 15% of migration period.
2	Facility operates between 15% and 25% of migration period.
1	Facility operates during more than 25% of the migration period.

NOAA Fisheries has developed fish screening criteria for anadromous salmonids, for both fingerling and fry life-history stages (NMFS 1997). Fish screens at diversion intakes should meet NOAA Fisheries criteria at all flow conditions. NOAA Fisheries defines fry as less than 60 millimeters (mm) in length. The following is a summary of the more important fish screen elements recommended by NOAA Fisheries for salmonid fry and juveniles. The criteria are presented for 1) pump intake design, 2) river and canal screen design, and 3) escape or return mechanism design.

1. Pump intake design.

    - Approach velocity not to exceed 0.33 fps for fry and 0.8 fps for juveniles.

    - Sweeping velocity to be greater than approach velocity.

    - Perforated plate screen opening not to exceed 3/32 inch in diameter for fry and ¼ inch for juveniles, and have a minimum open area of 27 percent for fry and 40 percent for juveniles.

    - Face of screen surfaces to allow fish unimpeded movement parallel to screen face and ready access to bypass routes.

    - Structural features to protect fish screens from large debris.

    - Design features to eliminate (as possible) undesirable hydraulic effects (e.g., eddies, stagnant flow zones) that may delay or injure fish, or provide predator opportunities.

    - Screen and bypass to work in tandem to move outmigrating salmonids (including adults) to the bypass outfall with minimum injury or delay.

    - Bypass entrance to be provided with independent flow control.

    - Bypass entrance must equal or exceed the maximum velocity vector resultant along screen, upstream of the entrance.

    - Bypass entrance to extend from floor to water surface; require smooth interior pipe surfaces and joints; fish to not free-fall; pressure in the bypass to be equal or be above atmospheric pressure; fish to not be pumped within the bypass system.

    - Bypass system to minimize debris clogging and be accessible for cleaning; depth of flow 0.75 foot or greater; ambient river velocities at bypass outfall greater than 4.0 fps.

    - Bypass outfall to be located to minimize avian and aquatic predation; bypass located where there is sufficient depth to avoid fish injury; impact velocity not to exceed 25.0 fps, bypass outfall discharges to be designed to avoid adult jumping injuries.

    - Fish screens to be automatically cleaned; fish screen system to be evaluated for biological effectiveness and available for inspection to NOAA Fisheries.

2. River and canal screens.

    - Where practical, construct screen at diversion entrance.

- Make screen face generally parallel to river flow and aligned with adjacent bankline.

- Minimize eddies and undesirable flow patterns in the vicinity of the screen.

- Provide sufficient hydraulic gradient to route fish between trash rack and screen to safety.

- Provide screens downstream of diversion entrance with an effective juvenile bypass system to collect juvenile fish and safely transport them back to the river with minimum delay. The angle of the screen to flow should be adequate to effectively guide fish to the bypass.

- If fish are entrained within a canal or infiltration pond, escape or return to the river can mitigate some of the effects. Alternatives are provided as criteria below, in order of preference.

3. Fish escape or return mechanisms.

   - Provide a structure that returns the fish safely to the river prior to entrapment in a canal or pond.

   - Provide a structure that allows the fish to voluntarily return to the river after entrainment.

   - Provide rescue of entrapped fish which minimizes stress, injury, and death through rapid response (rescue within one week), and design and/or methods of capture and release that reduce potential physical injury.

Fish screens are evaluated according to their performance standards and ability to pass juvenile and fry-sized salmonids within NOAA Fisheries criteria (Table C-10). A score of 5 is given to facilities that meet NOAA Fisheries criteria and pass fish without delay. A score of 3 is assigned to facilities with fish screens that pose a moderate risk of entrapment, but have rescue or escape mechanisms to reduce mortality. A score of 1 is assigned to facilities without fish screens and rescue or escape mechanisms.

Table C-10 Juvenile Passage Evaluation Criteria for Screen Design

Category Score	Evaluation Category
5	Fish screens meet NOAA Fisheries criteria and pass fish without injury or delay.
4	Facility provided with fish screens, but the facility has a low risk of entrainment, impingement, or migration delay.
3	Facility provided with fish screens, but the facility has a moderate risk of entrainment, impingement, or migration delay; effective rescue or escape is provided.
2	Facility provided with fish screens, but the facility has a high risk of entrainment, impingement, or migration delay; ineffective rescue or escape is provided.
1	Facility not provided with fish screens; no rescue or escape is provided.

C.1.5 PREDATION CRITERIA

Structures that concentrate predators and prey, or introduce predators into salmonid habitat they have not previously had access to, have the potential to increase predation on protected species. Examples of such a structure include a fish passage structure or a dam.

Predators of particular concern are non-native largemouth bass and smallmouth bass, green sunfish, and native Sacramento pikeminnow. There are currently self-sustaining populations of these warmwater species in the Russian River. In stream areas that are easily accessible to people, structures may provide increased poaching opportunities.

C.1.5.1 EVALUATION CRITERIA FOR PREDATION

Structures that concentrate prey increase the potential for predation on protected species. If there are holding areas that favor predators near structures that concentrate salmonids, and if predators are actually present near those structures, protected species may be negatively affected. Structures that provide predators access to areas that they have not historically reached would increase the level of predation by introducing a new risk. However, structures that provide predators access to areas with established populations of predators may or may not increase the level of predation. Furthermore, water temperatures favorable to predators would be needed.

To evaluate the risk of increased predation on protected species, three components were developed for predation evaluation criteria: structural criteria, access criteria, and habitat criteria. Structural criteria (Table C-11) assess whether the structure concentrates predators and prey. Access criteria (Table C-12) assess passage opportunities for predators and whether predators are given access to areas they have not historically had access to. Predator habitat criteria (Table C-13) are based on water temperatures favorable to warmwater predators, especially centrarchids and Sacramento pikeminnow. The optimum temperature for Sacramento pikeminnow is 26.3°C (Knight 1985). Warmwater temperatures favor these predatory fish at the same time that they negatively affect protected salmonids and their ability to avoid predation.

Table C-11 Predation Evaluation Criteria: Structural (Component 1)

Category Score	Evaluation Criteria
5	No features that concentrate salmonids or provide cover for predators, concentrations of predators not found.
4	No features that concentrate salmonids, predator cover near, predators in low abundance locally.
3	Features that concentrate salmonids, no predator cover nearby, predators in medium to low abundance locally.
2	Features that concentrate salmonids, predator cover nearby, predators in medium to low abundance locally.
1	Features that highly concentrate salmonids, predators abundant locally.

Table C-12 Predation Evaluation Criteria: Access (Component 2)

Category Score	Evaluation Criteria
5	Structure does not allow passage of predators; predators not present near structure.
4	Structure does not allow passage of predators; predators present near structure.
3	Structure provides limited passage of predators, or limited passage to areas they are already well established, predators not present near structure.
2	Structure provides limited passage of predators to areas they have historically not been found or have been found in limited numbers, predators present in limited numbers near structure.
1	Structure provides passage of predators to areas they have historically not been found or found in limited numbers, predators present or migrate to structure.

Table C-13 Predation Evaluation Criteria: Warmwater Species Temperature (Component 3)

Category Score	Evaluation Criteria
5	Water temperatures < 13^{o}C
4	Water temperatures 13^{o}C – 18^{o}C
3	Water temperatures 18^{o}C – 20^{o}C
2	Water temperatures 20^{o}C – 22^{o}C
1	Water temperatures 22^{o}C – 24^{o}C
0	Water temperatures $\geq 24^{o}$C

C.1.6 FLOOD CONTROL-RELATED CRITERIA

The USACE determines releases from Warm Springs Dam and Coyote Valley Dam from the flood control pool of the reservoirs. The magnitude and frequency of flow releases during flood control operations affect channel geomorphology, scour of spawning gravels, and the extent of bank erosion. The potential for these flood control activities to affect coho salmon, steelhead, and Chinook salmon habitat are discussed, and evaluation criteria are defined.

High flows are periodically required for channel maintenance to maintain variation in stream morphology important to habitat quality, such as meanders, pools, and riffles. Channel maintenance flows also serve to refresh spawning gravels by mobilizing the streambed and winnowing the fine sediments from the gravels. However, flood releases may affect spawning habitat by scouring gravels to a depth that destroys the egg pocket. Ideally, there would be a balance between periodic channel maintenance flows and stability of spawning gravels.

Flood control operations may affect channel geomorphology, including streambed and streambank stability and maintenance of channel equilibrium conditions (i.e., channel is neither aggrading or degrading over the long-term). Alterations in channel morphology can have a negative influence on fish habitat conditions. Bank erosion can increase sediment input that impairs spawning gravels by reducing the flow of oxygenated water and removal of metabolic wastes from redds. Alevins may also become entombed by fine sediment intrusion into spawning gravels. Pool habitat can be diminished by sedimentation. Streambank instability can reduce riparian vegetation. This results in a loss of cover habitat, increases in thermal loading by removing shade, and a reduction in the food supply by reducing the amount of terrestrial input. High-magnitude flood releases can scour spawning gravels, resulting in direct mortality of incubating embryos. Insufficient flows of moderate magnitude can alter the long-term balance of sediment supply and sediment transport, resulting in conditions of disequilibrium and channel aggradation.

Flood control releases from Warm Springs Dam and Coyote Valley Dam have reduced the magnitude of flood peaks in the Russian River drainage. Flood peaks are reduced when stored flood water is released over a longer period of time than would have naturally occurred. However, flood releases may still be of sufficient magnitude and duration to negatively affect spawning habitat if they scour gravels to a depth that destroys the egg pocket.

Sustained releases of flood flows have been cited as a potential cause of streambank instability on both Dry Creek and the mainstem Russian River. Prolonged discharges in excess of 2,500 cfs are believed to be responsible for accelerated bank erosion on Dry Creek (USACE 1999). Sustained releases of flood flows from Coyote Valley Dam are also cited as a contributor to streambank erosion on the mainstem Russian River (USACE 1999). However, for the mainstem Russian River there is no information on flow threshold at which bank erosion begins to occur. A flow threshold at which bank erosion was assumed to occur was developed and is described in Bank Erosion Evaluation Criteria in Section C.1.6.2.3. There are also no reports that specify which mainstem stream reaches are subject to erosion, except that “high sustained releases erode the river bank for miles downstream” (USACE 1998a).

C.1.6.1 CHANNEL MAINTENANCE/GEOMORPHOLOGY

The change in hydrologic regime associated with flow regulation by dams will influence channel geomorphic response (Collier, Webb and Schmidt 1996). The type and magnitude of adjustments depends on initial channel conditions and the extent of changes in discharge and sediment supply (Reiser and Ramey 1985). The effect of dams on the morphology of a river tends to diminish downstream due to discharge and sediment contributions from tributaries. Although the rate of channel change in response to flow regulation by dams is highly variable, most channel adjustments likely take place within a few decades following dam construction (Mount 1995).

Flow regulation by dam closure has reduced the magnitude of peak flood discharges at both Lake Sonoma and Lake Mendocino. In response, river channels typically modify their cross-sections by channel narrowing due to sediment deposition and encroachment by riparian vegetation. When the bed material is a sand and gravel mixture as on Dry Creek and the mainstem Russian River, channel incision will often accompany channel narrowing if the flood peaks are of sufficient magnitude to mobilize most of the bed materials. Excessive channel incision often results in over-steepened streambanks and subsequent erosion. If flood peaks are sufficiently reduced under flow regulation, then the coarser bed material will not be entrained, and only finer material will be transported, leading to an overall coarsening of the channel bed. At this point the river channel is armored, preventing further channel bed adjustments, although the streambank may remain susceptible to erosion. However, if flood peaks are substantially reduced so that there is little or no transport of coarse sediments, the channel response is likely to be aggradation. Coarse sediment supplied by local tributary input will exceed competence and lead to channel aggradation.

If flow regulation sufficiently reduces peak flood events so that the sediment transport regime is altered and coarsening of the channel bed or aggradation results, then fish habitat conditions may be negatively affected. Spawning gravels may be subject to accelerated rates of fine sediment intrusion, decreasing reproductive success. Increased sediment deposition in riffles may reduce benthic macroinvertebrate production, decreasing the available food base. Rearing habitat may also be affected due to sediment deposition in pools.

Dams and reservoirs interrupt sediment transport, which may lead to channel geomorphic changes. If a significant portion of the total sediment load is removed when coarse sediments are deposited within a reservoir, replenishment of sediments downstream will be reduced until there are sufficient sources of sediment input from downstream tributaries. This can lead to excess stream power immediately downstream of a dam, because relatively clear water with little sediment in transport can perform more work scouring sediments from the streambed, banks, and floodplain. Thus, entrainment of fine sediments below the reservoir may continue. Without sediment replenishment and with excess stream power, only the coarsest material may be left behind, leading to armoring of the channel bed.

To maintain channel geomorphic conditions, adequate flows are periodically needed to mobilize the streambed and transport sediments. Such flows are necessary to flush fine sediments from the streambed to provide suitable spawning and rearing conditions for salmonids. For example, since dam closure on the Trinity River, export of water and increase in sediment yields from the watershed have buried spawning habitat (Mount 1995). However, if flood releases are of sufficient magnitude and frequency to regularly scour redds, spawning may be negatively affected. This has occurred on the Sacramento River, where release of high peak discharges from Shasta Dam has led to widespread channel scouring and incision, leaving little spawning habitat and armored channels (Mount 1995). Ideally, there is a balance, or dynamic equilibrium, between periodic mobilization of the streambed, transport of sediment, and sediment deposition and stability of spawning gravels. Lack of peak flows can reduce spawning success, as can an increase in the frequency and magnitude of peak flows.

C.1.6.1.1 Changes Caused by Land-Use

The alteration of the flow regime associated with dams is not the only cause of changes in channel morphology. Land-uses and development in the Russian River watershed, including gravel extraction, agricultural practices, and urbanization, also influence channel geomorphic conditions. Clearing riparian vegetation, building roads, grazing, and other development activities can alter the flood hydrograph, increase bank erosion, increase sediment input from upland areas, and otherwise negatively influence channel geomorphic and aquatic habitat conditions. Land-uses that significantly increase or decrease (as in the case of gravel mining) sediment supply will cause as pronounced alterations in channel geomorphology as flood regulation by dams. Distinguishing the effects of flood-control operations separately from these land-use effects on channel conditions can be problematic.

Significant channel geomorphic changes were apparently already underway on Dry Creek before construction of Warm Springs Dam. A study conducted by USACE concluded that gravel mining on Dry Creek and on the mainstem Russian River had caused approximately 10 feet of incision along the 14-mile channel length by the mid-1970s (USACE 1987). The channel incision on Dry Creek initiated lateral instability and subsequent bank erosion so that channel width had increased from approximately 90 feet to over 450 feet in some locations in the 1970s (USACE 1987). The 1987 study concluded that it was unlikely that further channel degradation would occur, but that continued lateral instability and erosion of the incised channel banks was likely.

On the mainstem Russian River between Healdsburg and Ukiah, gravel mining has also recently altered channel geomorphic conditions. The East Fork Russian River had experienced up to 16 feet of channel bed degradation by the mid-1980s and in the Alexander Valley (near Cloverdale), approximately 2 feet of bed degradation had occurred by 1990 (EIP 1993).

C.1.6.2 Evaluation Criteria for Effects on Scour of Spawning Gravel, Streambank Erosion, and Channel Geomorphology

Evaluation criteria and analytical methods are described in detail for each of the channel geomorphic issues; scour of spawning gravel, streambank erosion, and channel geomorphology. All of the analyses consider how flood control operations affect those geomorphic issues. An important component of these analyses is related to expected streamflow conditions under flood control operations at Warm Springs Dam and Coyote Valley Dam. Streamflow has an important influence on channel geomorphic conditions and therefore on fish habitat.

Representative streamflow conditions were determined by using models rather than using actual, historic, streamflow data. The models provide a tool for simulating operational characteristics of the reservoirs and resulting streamflow conditions. As such, the hydrologic model emulates but does not necessarily match historic streamflow conditions exactly. The hydrologic model also has the advantage of being flexible. Operational conditions at each dam can be modified in the models so that streamflow conditions may be adjusted and the resulting potential change on geomorphic conditions and fish habitat tested.

For this report, two streamflow models were combined and used in the analyses. The SCWA model provides average daily flow at various locations along the mainstem Russian River between Coyote Valley Dam and Guerneville, and on Dry Creek downstream of Warm Springs Dam. The SCWA model was developed in the late 1980s to quantify relationships between streamflow, water demand, instream flow requirements, and water supply needs. The USACE HEC-5 model was developed specifically for this BA. This model also provides average daily flow at various locations along the mainstem Russian River between Coyote Valley Dam and Guerneville, and on Dry Creek downstream of Warm Springs Dam.

The results of the two models were combined so that flow conditions between June through October are derived from the SCWA model, and flow conditions between November through May are derived from the USACE model. The combined model results most accurately emulate historic flow conditions, since it was determined that the SCWA model did a better job of estimating low flow conditions, and the USACE model did a better job of estimating relatively high-flow conditions. The 36-year period of record covered by the combined model and used in all of the analyses are water years 1960 through 1995. For the remainder of this report, the combined flow model results are simply referred to as the hydrologic model.

C.1.6.2.1 Scour of Spawning Gravels Evaluation Criteria

Evaluation criteria for flood control effects on scour of spawning gravels were determined by estimating the hydraulic conditions necessary for the initiation of bed-particle motion. Incipient motion was derived from a modification of Shields' relationship for critical shear stress in non-uniform bed materials. Andrews (1983) determined that the average critical dimensionless shear stress for the median particle in the riverbed surface, $\tau *_{ci50}$, was 0.033. Andrews further found that in all rivers, the critical value of $\tau *_{ci50}$ was equaled or exceeded at the bankfull discharge. The mean bankfull dimensionless shear stress relative to the median particle diameter in the bed surface is 0.047. Thus, for an unarmored streambed, particles at least as large as the median diameter of the bed surface will be entrained by a bankfull discharge. Many hydraulic engineers and geomorphologists use 0.047 for critical dimensionless shear stress (Shields' parameter) in gravel bed streams (Simons and Li 1982), and this is the Shields value used in this assessment.

Using a Shields parameter of 0.047 for the mobilization of spawning-sized gravels on the bed surface, the Shields relationship for critical shear stress ($\tau *_{ci}$) is defined as:

$$\tau *_{ci} = 0.047 (\gamma_s - \gamma)d_{50}$$

Where:

γ, γ_s = specific weight of the fluid and sediment, respectively
$_{50}$ = median particle diameter

Thus, critical shear (the threshold at which incipient motion occurs) can be calculated for a particle size distribution with a known median diameter (d_{50}). There are no data available for the size of spawning gravels used by salmon and trout on either Dry Creek or the mainstem Russian River. For this analysis, the d_{50} (median particle diameter) of spawning-sized gravels was assumed to be as follows:

Coho Salmon	16 mm
Steelhead	22 mm
Chinook Salmon	36 mm

These d_{50} are based on a compilation of spawning gravel particle sizes reported from numerous studies on streams throughout the western states (Kondolf and Wolman 1993). The range of d_{50} represented by the 25th, 50th, and 75th percentile values from these studies are shown in Table C-14. The percentile values refer to the frequency distribution of d_{50} spawning gravel particle sizes associated with each species in the compiled studies. Thus, a 75th percentile value indicates that only 25 percent of the d_{50} particle size values exceed the value listed in Table C-14. The 50th percentile is synonymous with the median, indicating that one-half of the d_{50} particle sizes were greater than, and one-half less than, the listed values.

Table C-14 D_{50} Spawning Gravel Sizes Compiled by Kondolf and Wolman (1993)

	25th Percentile	50th Percentile	75th Percentile
Coho Salmon	12	16	30
Steelhead	18	22	32
Chinook Salmon	22	36	48

The critical shear stress calculated using a Shields parameter of 0.047 for the d_{50} of spawning gravels in coho salmon, steelhead, and Chinook salmon redds are shown in Table C-15.

Table C-15 Critical Shear Stress for Coho Salmon, Steelhead, and Chinook Salmon Spawning Gravels

	D_{50} (mm)	Shields Parameter	Critical Shear (lbs/ft^2)
Coho Salmon	22	.047	.349
Steelhead	16	.047	.254
Chinook Salmon	36	.047	.572

The critical shear stress was compared with values of actual shear stress for a range of flood-flow discharges on Dry Creek and the mainstem Russian River between Healdsburg and Ukiah in two distinct stream reaches: Alexander Valley and upstream of

Alexander Valley to Ukiah. Average shear stress values were determined for individual cross-sections using HEC-RAS hydraulic modeling. On Dry Creek, average bed-shear stress values were calculated for 112 cross-sections. These cross-sections were surveyed by SCWA. On the mainstem Russian River, 56 cross-sections located downstream of Coyote Valley Dam were used to determine shear stress values. Of the 56 cross-sections, 30 were surveyed in the Alexander Valley for the SCWA Aggregate Resources Mining Plan (SCWA 1999) in 1998, and 26 were surveyed upstream of Alexander Valley to Ukiah in 1978 by Winzler and Kelly for USACE (1978). Since the effect of flood control operations from Coyote Valley Dam is insignificant below Healdsburg, and spawning is not considered to be significant on the lower mainstem reach (Winzler and Kelly 1978, Steiner 1996), no analysis was performed below Alexander Valley.

Actual shear stress values (calculated using HEC-RAS) that exceed the critical shear threshold identified in Table C-16 can be expected to initiate motion in redd gravels. Initiation of motion occurs when critical shear stress is exceeded by actual channel-bottom shear stress, although the transport rate and distance of transport of the streambed material may be quite small when the critical shear stress is only slightly exceeded.

To confirm that initiation of motion associated with a given discharge is likely to be sufficient to scour redd gravels to the depth of a typical egg pocket, a second, supporting analysis was performed to estimate depth of scour. The amount of scour in a riverbed depends on the ability of the bed to reform the surface layer after it has been ruptured. To make such a determination, the size of the streambed sediments must be known from field studies. The streambed particle size that will not move with a given discharge is determined. This is accomplished by comparing the critical shear stress needed to move a given particle size, (determined by the Shield's relationship), with the actual particle shear stress for that discharge. The actual particle shear stress can be derived from the velocity associated with the given flow. By observing the percentage of bed material less than the size of the maximum sediment which will not move, the depth of scour necessary to leave an armor layer can be calculated by the equation (Simons & Associates 1987):

$$\Delta Z = 2\ d_a/1\text{-}P_c$$

where:

ΔZ is the depth of scour

d_a is the size of the armoring material

P_c is the percent of material finer than the maximum moveable size

The greater the percent of streambed material finer than the maximum moveable size, the greater the depth of scour. Conversely, the smaller the percent of streambed material finer than the maximum moveable particle size, the smaller the depth of scour.

The maximum moveable size of streambed material (d_a) was determined from a defined relationship between flow velocity and sediment size (EIP 1993, based Simons &

Associates 1987). The average flow velocity at the discharge which initiates motion was determined from HEC-RAS model output for each cross-section. The average flow velocity is entered on the curve to determine the maximum moveable size of streambed material.

There are no available particle-size distribution curves from actually spawned gravels on either Dry Creek or the mainstem Russian River. For Dry Creek, the size distributions used to determine the percentage of bed material finer than the maximum moveable sediment size (P_c) is based on particle-size distribution data obtained from bed material grab samples (USACE 1987). Thirteen particle-size distribution curves, each representing a different location along the Dry Creek channel profile, were developed from USACE 1987 data and from twelve particle-size distribution curves developed from USACE 1999 data. For the mainstem Russian River, Alexander Valley to Ukiah, five particle-size distribution curves developed from recent 1999 bulk sampling in riffles performed by SCWA were used.

The streambed degradation analysis provides an estimate of depth to which scour will occur, confirming if redds are likely to be disturbed to the depth of the egg pocket. The average egg pocket depth for coho salmon, steelhead, and Chinook salmon is 20 to 30 centimeters (cm) (7.9 to 11.8 inches) (Bjornn and Reiser 1991). For this analysis, depth to the egg pocket was assumed to be 8 inches (0.7 feet) (B. Cox, CDFG, pers. comm. 2000).

The analysis for influence of flood operations on scour of spawning gravels is based on the following procedure:

1) Shear stress values determined in the HEC-RAS model are compared with the critical shear thresholds defined in Table C-15 and used to determine the discharge at which initiation of motion will occur. The number of cross-sections expected to have initiation of motion for specified flow ranges are identified in (Tables C-16 to C-22). The number of cross-sections at which spawning-sized gravels will likely not experience initiation of motion given the existing hydrologic regime is also identified in each table. Three tables are presented for Dry Creek, one for each species. On the mainstem Russian River only steelhead and Chinook salmon gravels are evaluated, since coho salmon do not spawn on the mainstem.

Initiation of motion associated with the range of discharges is plotted as cumulative curves for each species using Tables C-16 to C-22. The initiation of motion curves show the cumulative number of cross-sections at which shear stress exceeds critical shear.

2) The number of flood events that occur in the designated flow categories (Tables C-16 to C-22) are tallied for the period of record, water years 1960 to 1995, derived from flow modeling. The flow modeling represents the range of streamflow conditions expected under present-day flood control operations of Warm Springs Dam and Coyote Valley Dam. The flow modeling is not an evaluation of actual historic conditions, but rather a tool which characterizes the magnitude and frequency of representative runoff conditions over time.

3) An ordinal ranking score is applied to all flood events for each of the defined flow categories based on the different time periods when the flows occur and based on each of the three fish species of concern. The ordinal ranking score, 1 to 5, assigns a 1 to the highest potential effect and a 5 to the lowest potential effect. High potential for effects (i.e., low ordinal ranking) was assigned to higher flows and flows which occur during the latter part of the spawning and incubation season. Those flows have the greatest potential to scour the most redds and incubating alevins. The criteria for scoring are defined for each of the stream reaches and for each species as shown in Tables C-23 to C-29.

4) Depth of scour is calculated to determine if the 0.7-foot criterion is exceeded for the discharge range associated with initiation of motion.

Dry Creek

Table C-16 Steelhead Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-Sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<1,300 cfs	25	22
>1,300-2,600 cfs	27	46
>2,600-5,500 cfs	32	75
>5,500 cfs	24	96

Never moved: 4 cross-sections = 4% of total 112

Table C-17 Chinook Salmon Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-Sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<3,000 cfs	21	19
>3,000-6,000 cfs	25	41
>6,000-9,000 cfs	20	61
>9,000 cfs	18	79

Never moved: 24 cross-sections = 21% of total 112.
Note: discharge greater than 8,000 cfs has not occurred on Dry Creek.

Table C-18 Coho Salmon Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-Sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<800 cfs	28	25
>800-1,400 cfs	27	49
>1,400-3,000 cfs	29	75
>3,000 cfs	26	98

Never moved: 2 = 2% of cross-sections.

Mainstem Russian River in Alexander Valley

Table C-19 Steelhead Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-Sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<2,000 cfs	7	23
>2,000-5,000 cfs	8	50
>5,000-12,000 cfs	7	73
>12,000-24,000 cfs	7	97

Never moved: 1 cross-section = 2% of total 30.

Table C-20 Chinook Salmon Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-Sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<5,000 cfs	6	20
>5,000-18,000 cfs	9	50
>18,000-27,000 cfs	7	75

Never moved: 8 cross-sections = 25% of total 30.

Mainstem Russian River Upstream of Alexander Valley to Ukiah

Table C-21 Steelhead Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<500 cfs	10	38
>500 cfs	7	65

Never moved: 9 cross-sections = 35% of total 26.

Table C-22 Chinook Salmon Spawning Gravels: Number of Cross-Sections with Initiation of Motion

Flow Range	Number of Cross-sections with Initiation of Motion in Given Flow Range	Cumulative Percent Moved (%)
<1,000 cfs	5	19
>1,000 cfs	4	38

Never moved: 16 cross-sections = 62% of total 26.

Scoring

The scoring system shown in Tables C-23 to C-29 is based on the number of cross-sections that will initiate bed movement within each of the stream reaches evaluated. As flows increase and more cross-sections experience bed movement, scores are lower. Whenever possible, at approximately every 20 percent to 25 percent incremental change in the number of cross-sections moved, the corresponding ordinal ranking scores are lowered by 1. Thus, the first 20 percent of the cross-sections moved in the given flow range is given a 5, the next 20 percent (i.e., cumulative of 40 percent moved) receives a 4, and so on. Scores do not go to 0 at any of the locations because there were always some cross-sections at which shear values never attain the critical shear threshold, so there is no initiation of motion. This occurred at several of the most upstream cross-sections on the mainstem Russian River where large streamflows overbank and fill the floodplain before critical shear is attained.[1] This also occurs at some of the wider cross-sections that do not obtain sufficient depth of flow to generate the shear stress necessary to initiate motion of spawning-sized gravels. Ordinal ranking scores do not reach the lower values when a relatively large percentage of the cross-section's shear values do not exceed critical shear threshold over the flow range (e.g., see Tables C-28 and C-29).

The first time-period in each of the tables below is the estimated period before spawning is over, and the second estimated time-period is during incubation after spawning is over.

[1] This is one important function of floodplains. By allowing overbank flows, there is "hydraulic release," limiting the magnitude of bed shear stress.

Scores are lower during the incubation time-period to reflect the fact that flows which disrupt spawning gravels with incubating eggs will likely have a greater negative effect on reproductive success for that year's class. Each of the daily flows from the hydrologic modeling record was scored for the relevant spawning and incubation time periods. The final score given for each water year is the highest impact event that occurs during the year.

Dry Creek

Table C-23 Coho Salmon Scoring Criteria for Scour of Redds in Dry Creek

Flow Range	Coho Salmon Dec 1–Jan 31 (before spawning is over)	Coho Salmon Feb 1–Feb 28 (incubation)
<800 cfs	5	5
>800 – 1,400 cfs	4	3
>1,400 – 3,000 cfs	3	2
>3,000 – 8,700 cfs	2	1

Table C-24 Chinook Salmon Scoring Criteria for Scour of Redds in Dry Creek

Flow Range	Chinook Salmon Nov 1-Jan 31 (before spawning is over)	Chinook Salmon Feb 1-Mar 31 (incubation)
<3,000 cfs	5	5
>3,000 – 6,000 cfs	4	3
>6,000 – 9,000 cfs	3	2
>9,000 – 15,000 cfs	2	1

Table C-25 Steelhead Scoring Criteria for Scour of Redds in Dry Creek

Flow Range	Steelhead Dec 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)
<1,300 cfs	5	5
>1,300 – 2,600 cfs	4	3
>2,600 – 5,500 cfs	3	2
>5,500 – 12,000 cfs	2	1

Mainstem Russian River in Alexander Valley

Because coho salmon do not utilize the mainstem Russian River for spawning, only scour of Chinook salmon and steelhead spawning gravels were evaluated.

Table C-26 Chinook Salmon Scoring Criteria for Scour of Redds in Alexander Valley

Flow Range	Chinook Salmon Nov 1-Jan 31 (before spawning is over)	Chinook Salmon Feb 1-Mar 31 (incubation)
<5,000 cfs	5	5
>5,000 – 18,000 cfs	4	3
>18,000 – 27,000 cfs	3	2

Table C-27 Steelhead Scoring Criteria for Scour of Redds in Alexander Valley

Flow Range	Steelhead Dec 1-April 30 (before spawning is over)	Steelhead May 1-May 31 (incubation)
<2,000 cfs	5	5
>2,000 – 5,000 cfs	4	3
>5,000 – 12,000 cfs	3	2
>12,000 – 24,000 cfs	2	1

Mainstem Russian River Upstream of Alexander Valley to Ukiah

Table C-28 Chinook Salmon Scoring Criteria for Scour of Redds in the Upper Mainstem Russian River

Flow Range	Chinook Salmon Nov 1-Jan 30 (before spawning is over)	Chinook Salmon Feb 1-Mar 30 (incubation)
<1,000 cfs	5	5
>1,000 cfs	4	3

Table C-29 Steelhead Scoring Criteria for Scour of Redds in the Upper Mainstem Russian River

Flow Range	Steelhead Dec 1-April 30 (before spawning is over)	Steelhead May 1-May 30 (incubation)
<500 cfs	5	5
>500 cfs	4	3

Because the effect of flood control operations from Coyote Valley Dam is insignificant below Healdsburg, and spawning is not considered to be significant on the lower mainstem reach (Winzler and Kelly 1978, Steiner 1996), no analysis was performed below Alexander Valley.

C.1.6.2.2 Bank Erosion Evaluation Criteria

On Dry Creek, criteria for evaluation of streambank stability effects are based on an analysis of the frequency of flood flows greater than 2,500 cfs. Prolonged discharges in excess of 2,500 cfs are responsible for accelerating bank erosion on Dry Creek (USACE Biological Assessment 1999). Daily average flow from the hydrologic model was used for the assessment. For each year in the period of record (1960-1995), flows greater than 2,500 cfs were tallied. Scoring is based on the percentage of time in each water year that exceeds 2,500 cfs, as shown in Table C-30. The greater the number of days in any given year with flows exceeding 2,500 cfs, the lower the score. For years with flows greater than 2,500 cfs occurring less than 1 percent of the time (i.e., 3 days or less per year), a score of 5 is applied. For years with 2,500 cfs or greater magnitude flows occurring more than 4 percent of the time in any given year (16 or more days), a score of 1 is applied.

Table C-30 Evaluation Criteria for Dry Creek Streambank Stability

Percent of Time Flows Greater than 2,500 cfs	Number of Days per Year	Score
<1%	3 or less	5
1% – 2%	4 – 7	4
>2% – 3%	8 – 11	3
>3% – 4%	12 – 15	2
>4%	16 or more	1

No flow threshold has been specified at which bank erosion occurs on the mainstem Russian River. Therefore, the same unregulated recurrence interval flood that initiates bank erosion on Dry Creek was selected as the flow at which bank erosion is initiated on the mainstem below Coyote Valley Dam. On Dry Creek, the flow which initiates bank erosion, 2,500 cfs, corresponds to an 88 percent exceedance flow (as a 1-day annual maximum) or a 1.1-year, 1-day recurrence interval flood under unregulated conditions. This is slightly greater than the annual flood, which over the long-term will be equaled or exceeded approximately once every year. The 1.1-year, 1-day flood under unregulated conditions is 6,000 cfs at Hopland and 8,000 cfs at Cloverdale.

The analytical approach for flood operation effects on mainstem Russian River bank erosion is the same as for Dry Creek, using 6,000 cfs at Hopland and 8,000 cfs at Cloverdale. Scoring criteria for both locations are shown in Table C-31. Streambank erosion was not considered further downstream since the ability to control flood flows becomes greatly diminished at Healdsburg.

Table C-31 Scoring Criteria for Mainstem Russian River Streambank Stability

Percent of Time Flows >6,000 cfs at Hopland and >8,000 cfs at Cloverdale	Number of Days per Year	Score
<1%	3 or less	5
1% – 2%	4 – 7	4
>2% – 3%	8 – 11	3
>3% – 4%	12 – 15	2
>4%	16 or more	1

Flow changes above 1,000 cfs/hr are generally limited to a rate of 1,000 cfs/hr (interim ramping guidelines) to protect against bank sloughing and are not related to fish stranding issues. There may be a relationship between the rate at which flows are ramped down and the potential for saturated streambanks with high-pore pressures to slough. However, there are no data available on either Dry Creek or the mainstem Russian River to relate high flow recession rates to incidences of bank erosion.

C.1.6.2.3 Channel Maintenance/Geomorphology Evaluation Criteria

There is no single, well-established methodology to determine how regulated flood flows may change channel geomorphology or affect fish habitat. An equilibrium channel morphology (stream channel is neither aggrading nor degrading over the long-term) is maintained by flows that mobilize the streambed surface, transporting bedload at a rate is approximately equal to sediment supply. Maintaining the frequency of incipient motion of the channel bed is often used as a minimum criteria for maintenance of channel morphological conditions. It is characteristic for alluvial channels to have incipient mobilization of the channel bed at discharges that are approximately 80 percent of the 1.5- to 2.0-year annual maximum flood stage height (bankfull stage) (Andrews 1983). Typically, the 1.5- to 2.0-year annual maximum flood is considered to be the flow which, over the long-term, will do the most work in transporting sediments and is therefore defined as the effective or “channel-forming” discharge (Leopold 1994).

Maintenance of geomorphic conditions is based on the channel-forming 1.5-year annual maximum flood flow, shown in Table C-32. The 1.5-year flow can be expected to occur approximately twice out of every 3 years, or 66 percent of the time. Thus, for the 36-year period of record available from the hydrologic model, there should be approximately 24 flood flows that occur as annual peaks that equal or exceed the 1.5-year flood.

Scoring criteria consider how often the flow regime equals or exceeds the natural channel-forming discharge (1.5-year annual maximum flood flow). If the current flow regime achieves or exceeds the natural 1.5-year annual maximum flood magnitude in approximately two-thirds of the years over the simulated period of record (approximately 24 years out of 36 years), then channel maintenance is maximized, and the score is 5. If the current flow regime does not meet or exceed the natural channel-forming flow as frequently, then channel maintenance is not maximized, and lower corresponding scores are given.

The hydrologic modeling provides a simulated representation of average daily flow for the period of record. The 1.5-year channel-forming flow is calculated based on the annual instantaneous peak discharge, which will always be greater than the average daily flow. Therefore, to perform this assessment, it was necessary to estimate the average daily flow that corresponds to the 1.5-year instantaneous peak discharge. The corresponding average 1-day discharge was previously calculated by USACE (1998b), and is shown in Table C-32. The 1-day, 1.5-year annual flood flow is used as the criteria for this analysis. The assumption is that the 1-day flood flow includes the instantaneous peak flow that corresponds to the channel-forming discharge. This assumption may not be strictly true close to the dams, because flood-flow releases are controlled and relatively evenly distributed throughout the day (Paul Pugner, USACE, pers. comm. 2000). However, with distance downstream from the release point, the contributing drainage area will make up an increasingly larger proportion of the streamflow, resulting in higher instantaneous peaks contained within the average daily discharge.

Table C-32 Channel Maintenance Flow Associated with the 1.5-Year Peak Discharge and 1.5-Year 1-Day Discharge

	1.5-Year Peak Discharge	1.5-Year 1-Day Discharge
Dry Creek below Warm Springs Dam	9,500	5,000
Dry Creek near Geyserville	11,000	7,000
Russian River at Hopland	14,500	9,500
Russian River at Cloverdale	18,000	14,000
Russian River at Healdsburg	25,000	21,000

Note: 1.5-year unregulated flow for peak and 1-day discharge from USACE flood-frequency curves.

Scoring criteria are shown in Table C-33. A single score is given for the entire period of record (water years 1960 to 1995). Any single-year alone does not encompass a sufficiently long time-period to assess whether flood control operations are adequate to maintain channel geomorphic conditions. By definition, the channel-forming flow should occur approximately twice out of every 3 years, as a long-term average. When the channel-forming flow occurs less frequently, lower scores are applied. If the maximum annual discharge never meets or exceeds the threshold for the natural channel-forming flow, the score is 0. Channel-forming flows that occur more frequently received correspondingly higher scores (see Table C-33). The scoring applies equally to coho salmon, steelhead, and Chinook salmon.

Table C-33 Scoring Criteria for Maintenance of Channel Geomorphic Conditions

Proportion of Years with Channel Maintenance Flows	Number of Years per 36-Year Period of Record[a]	Score
51% – 66%	19 – 24	5
36% – 50%	14 – 18	4
21% – 35%	8 – 13	3
11% – 20%	5 – 7	2
1% – 10%	4 or less	1
0%	0	0

[a] Multiple channel-forming flows that may occur in a single year are counted as one occurrence for that year.

C.1.7 Fish Stranding Criteria

Ramping rates (reductions in flow) during dam maintenance activities or flood control operations have the potential to strand fish.

Recent research in Washington indicates that natural flow recessions associated with the annual snowmelt hydrograph occur at a very slow rate and tend to reduce the likelihood of stranding of small salmonids (Hunter 1992). If discharge is decreased too rapidly by flow regulation, then juvenile, or even adult salmon, can be stranded and killed. Project operations that have the potential to cause rapid flow fluctuations include operations at Coyote Valley Dam, Warm Springs Dam, and the inflatable dam at Mirabel.

Juveniles, particularly fry, are more susceptible to stranding than adults. Once Chinook salmon grow 50 mm to 60 mm or steelhead grow to 40 mm, they are substantially less vulnerable, but adult stranding has also been documented (Hunter 1992). Fry that have just absorbed the yolk sac and have recently emerged from the gravel are the most vulnerable because they are poor swimmers and typically reside along shallow stream margins (Phinney 1974, Woodin 1984). Stranding of juvenile coho salmon and rainbow trout on a gravel substrate in an artificial stream at low temperature was less frequent at slow rates of dewatering (6 cm/hr stage change rather than 30 cm/hr) and if flow reductions occurred at night (Bradford, et al. 1995). Stranding of juvenile coho salmon was reduced when the slope of the bar exceeded 6 percent.

The behavioral response of fish to flow fluctuations and how it may cause downstream emigration is not well understood. Studies conducted during the early 1970s by McPhee and Brusven (1976, cited in Hunter 1992) demonstrate that streamflow fluctuations trigger benthic drift and cause juvenile salmon to migrate downstream. Streamflow fluctuations can also cause both juvenile and adult fish to become trapped in shallow areas that are then exposed to elevated temperature or predation.

Redds are also susceptible to lowering water levels. Salmonid eggs can survive for weeks in dewatered gravel if they remain moist and are not frozen or subjected to high temperatures. However, dewatering is lethal to alevins. Since salmonids spawn over a period of months, eggs and alevins are often present at the same time.

Ramping rates typically constrain the rate (cfs/hr) at which a controlled release can be changed. Ramping rates are important to fisheries management agencies because they affect the rate at which instream hydraulic, and therefore habitat conditions, can be changed. The rate at which a controlled release is changed affects the rate at which total streamflow and downstream flow depths, flow velocities, channel top widths, and wetted surface areas change. The degree to which a particular ramping rate affects instream hydraulic and habitat conditions depends upon several site-specific factors:

- Percentage of total streamflow affected by the ramped release
- Amount of streamflow during ramping
- Stream channel shape, cross-sectional area, and slope
- Downstream distance from the ramping location

Perhaps the most difficult factor to understand quantitatively is the degree to which a flow change is "attenuated" as it progresses downstream. The influence of a sudden change in flow on stage is most pronounced at the location where the change occurs and decreases rapidly in the downstream direction. If a controlled release is ramped up, a portion of the released water goes into channel storage rather than directly into streamflow. Channel storage is represented by that portion of the channel cross-section over which the increased flow is spread, or temporarily "stored," along the channel length. This reduces the amount of flow and moderates the resulting change in water surface elevation (WSE) (stage) observed downstream from the point of ramping. If the controlled release is ramped down, a portion of channel storage is "evacuated" to become streamflow. The rate and degree to which channel storage changes influence stage primarily depends upon the size of the flow change (ramping) relative to streamflow and channel size, cross-sectional area, channel shape, and slope. Tributary inflow is also important. As tributary inflow contributes to streamflow in the channel, the relative effect of ramping represents a proportionally smaller influence on total channel flow and associated change in stage.

For analysis of ramping rates on Dry Creek, attenuation is assumed to occur within 1.0 to 1.5 miles downstream of Warm Springs Dam, which is the location of the first major tributary input at Pena Creek. On the mainstem Russian River, ramping effects are assumed to be attenuated by approximately 5 miles or less downstream of Coyote Dam near the Perkins Street bridge crossing in Ukiah. At the Forks, there is usually considerable flow from the mainstem Russian River during flood control operations that would attenuate ramping effects. Flows of approximately 2,500 cfs on the mainstem Russian River influence backwater effects on the East Fork (Pugner, USACE, pers. comm. 2000). Flow in the mainstem Russian River is usually increasing as reservoir releases are reduced during flood control operations, which moderates the ramping effects.

Table C-34 outlines the periods when salmonid fry may be present. Rearing coho salmon and steelhead fry may be present in Dry Creek in late winter and spring. Additionally, steelhead and coho salmon juveniles may be present in Dry Creek. In the mainstem Russian River below Coyote Valley Dam, Chinook salmon and steelhead fry as well as coho salmon, steelhead, and Chinook salmon juveniles, may be present during various times in the year. The critical issues addressed for operations of Coyote Valley Dam are reduced instream flow effects on habitat conditions and the potential for stranding below the dam. Below Warm Springs Dam, the critical issue is reduced streamflow effects on habitat conditions.

Table C-34 Times When Fry May Be Present in the Russian River Drainage

Species	Emergence	Fry may be present
Coho Salmon	Feb 1 – March 31	Feb – April
Steelhead	March 1 – May 31	March – June
Chinook Salmon	Feb 1 – March 31	Feb – April

Stress is likely to occur when fish are displaced from established rearing areas and crowded into residual pools. Residual pools with high fish densities could be subject to food competition, or predation by avian species and vertebrates, including hatchery fish preying on wild fish. Stranding could occur on riffles, gravel bars, and in backwater pools if flow becomes intermittent, and mortality may result if fish become desiccated. Water temperatures could also be elevated.

The Washington Department of Fisheries has proposed a rate of stage change that will generally protect fish (Hunter 1992). Hunter’s ramping guidelines are modified with the phenology of salmonids in the Russian River Basin for this assessment (Table C-35).

Table C-35 Rates of Stage-Change Based on Hunter (1992) and Life-History Stages for Salmon and Steelhead in the Russian River Basin

Season	Rates
March 1 to July 1	1 inch/hour (0.08 foot/hour)
June 1 to November 1	2 inches/hour (0.16 foot/hour)

Drawing from Hunter’s proposed guidelines, during juvenile rearing periods, which occur year-round for steelhead and coho salmon in the Russian River Basin, 2 inches/hour (0.16 foot/hr) stage change is appropriate. In the Mirabel Rubber Dam Fish Sampling Program (Chase et al. 2000), data from SCWA’s sampling program at Mirabel provide and indication of the size of salmonids in this portion of the mainstem (Chase et al. 2000, 2001, 2002, 2003). Chinook salmon averaged approximately 35 to 40 mm FL during the first few weeks of their life in 2002, then quickly grew to an average of approximately 80 mm by mid-April. The large numbers of steelhead YOY observed in 2002 (as in 2000) suggests that steelhead spawn and rear in the mainstem Russian River. Steelhead YOY became abundant in mid-April 2002 at an average FL of approximately 40 mm. The average size of steelhead YOY increased form 44 mm to 84 mm between April and June

2000. A few steelhead YOY captured in the Wohler Pool during August 2000 electrofishing surveys were generally larger than similar aged steelhead captured in Mark West and Santa Rosa creeks during fall surveys (Chase et al. 2000), suggesting mainstem-reared fish may have higher growth rates.

The Hunter (1992) guidelines are considered to represent a rigorous and conservative ramping standard for the Russian River watershed. Hunter developed his guidelines based on streams located in the northwest, a hydrologic regime that is dominated by snowmelt processes. Snowmelt streams usually have relatively gradual changes in runoff conditions. In the Russian River drainage, streamflow is driven by often intense Pacific frontal storms that naturally result in very “flashy” runoff conditions and therefore relatively larger changes in stage compared with snowmelt runoff conditions.

A comparison of the Hunter guidelines with natural flow recessions following storm events in the Russian River demonstrates this point. Stage changes associated with the receding limb of storm events were reviewed for the U.S. Geological Survey (USGS) Ukiah gage (11461000) located above the Forks and were compared to the Hunter guidelines (Figure C-1). For the period November 1995-June 1999, the average stage change is approximately 0.3 to 0.4 foot/hr when flows are greater than 1,500 cfs. At the 90^{th} percentile, stage changes range from 0.4 to 0.5 foot/hr or more when flows are greater than 1,500 cfs.

C.1.7.1 Flood Control Operations

To protect spawning gravel and juvenile salmonids within the Russian River and Dry Creek during flood control operations, USACE, in consultation with NOAA Fisheries and CDFG, developed interim guidelines for flow release changes. Proposed ramping rates for low reservoir outflows (0 to 250 cfs) are lower. These ramping rates summarized as follows:

Reservoir Outflow	Interim Ramping Rate	Proposed Ramping Rate
0 to 250 cfs	125 cfs/hr	25 cfs/hr
250 to 1,000 cfs	250 cfs/hr	250 cfs/hr
>1,000 cfs	1,000 cfs/hr	1,000 cfs/hr

The maximum ramping rates at release levels below 1,000 cfs differ from authorized rates. However, every effort is made to comply with the interim rates (USACE 1998a,b). These ramping rates are intended for flood control activities only. Flow changes above 1,000 cfs release are generally limited to a rate of 1,000 cfs/hr to protect against bank sloughing and are not related to fish stranding issues. Lower ramping rates at lower reservoir flow releases are to protect against fish stranding. The ramping rate guidelines are followed for flood operations that ramp flows down as well as releases that ramp flows up (Bond, USACE, pers. comm., 2000).

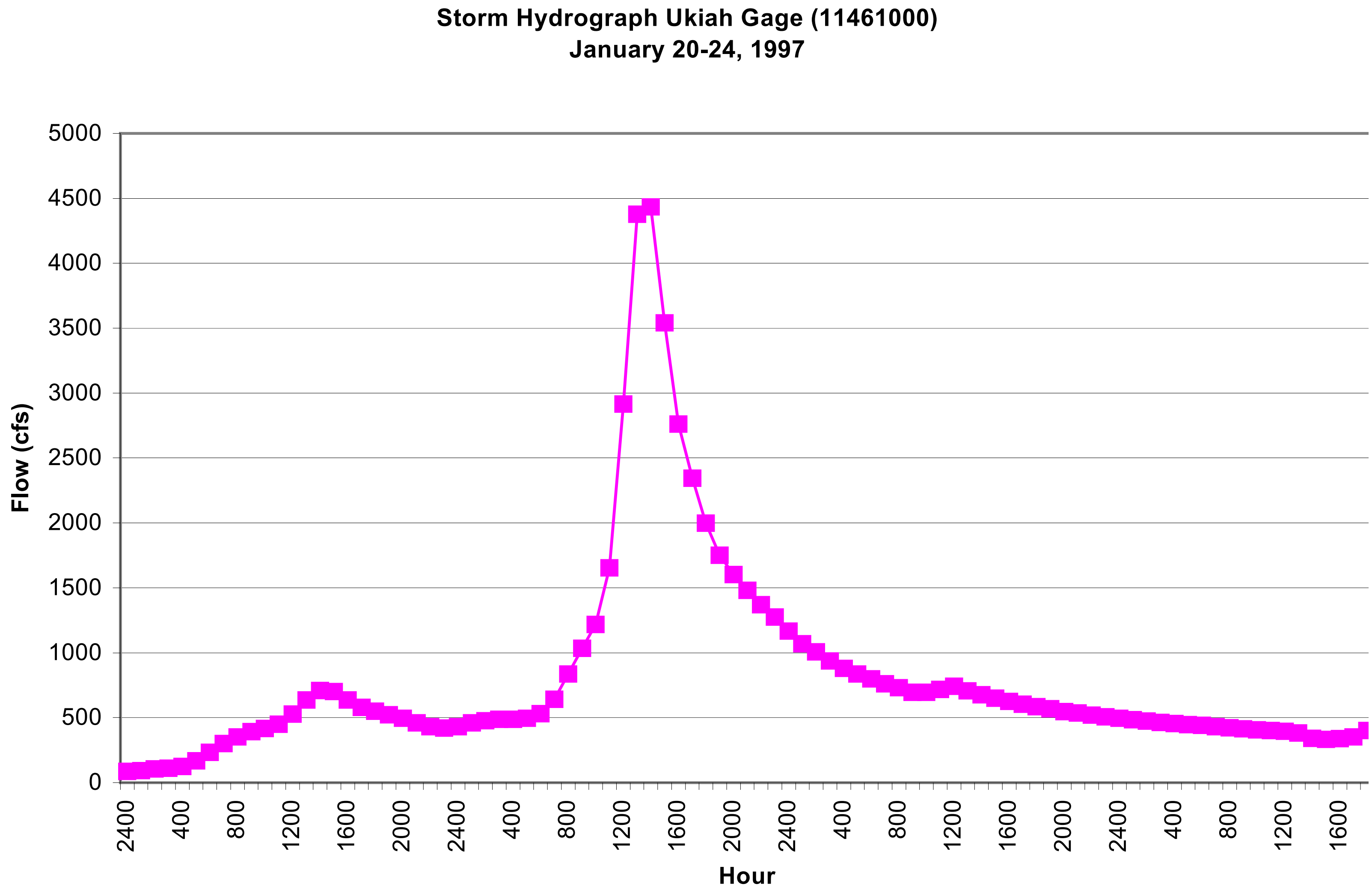

Figure C-1 Storm Hydrograph Ukiah Gage

It is unlikely that ramping-up rates associated with flood control operations would have an effect on listed species. Dam releases during flood control operations are made when downstream tributary flows are receding after a storm event, thereby reducing rather than augmenting natural flood peaks. Ramping-up rates follow the interim guidelines, so that when release flows are above 1,000 cfs, ramping occurs at no more than 1,000 cfs/hr.

This ramping rate is lower than natural flow increases associated with storm events. The USGS gage at Ukiah (11461000) located above the Forks was inspected and evaluated for natural flow changes for the period November 1995 to June 1999. Flows at the Ukiah gage are not regulated, and therefore represent natural flow fluctuations. On the rising limb of the storm hydrograph, hourly increases in flows above 1,500 cfs average 390 cfs/hr, and 10 percent of the time (90^{th} percentile) exceed 960 cfs/hr. A storm hydrograph for January 20 to 24, 1997 is shown in Figure C-1. From USGS stage data for this station, the maximum stage change associated with the rising limb of this storm event is approximately 1.9 feet/hr. The stage change associated with the average 390 cfs/hr increase in flows is approximately 0.5 foot (when flows are greater than 1,000 cfs). These data indicate that natural stage changes are sometimes greater than the Hunter criteria.

C.1.7.2 Dam Inspection and Maintenance

In addition to ramping during flood control operations, change in flow releases from Warm Springs Dam and Coyote Valley Dam are scheduled annually for dam maintenance and inspection activities. To perform the annual and periodic dam inspection and maintenance work, ramping-down flow releases is necessary for conduit inspections. Ramping rates during dam inspection and maintenance have in recent years been determined by consultation between USACE and NOAA Fisheries prior to each year’s annual inspection.

In addition to regular pre-flood inspection and maintenance activities, both dams have historically required infrequent but important testing of the outlet works to verify safe operation of the projects. Testing may include investigations to determine damages, identify the cause of damages, and verify the reliability of outlet works and changes in Standard Operating Procedures to insure the continued operational integrity of the project. The flow releases necessary for testing are not the same as those required for pre-flood inspection and maintenance activities. Testing flow releases is variable, and the need to conduct testing may arise at anytime throughout the year. An example of dam safety testing is the vibration analysis conducted in January, February, and March 1998 at Warm Springs Dam, where outflow varied between 50 cfs and 3,000 cfs. This testing was performed to investigate the reliability of the outlet works and to insure the continued safe operation of the dam.

C.1.7.3 Ramping Rate Evaluation Criteria for Warm Springs and Coyote Valley Dams

Evaluation criteria were developed to assess effects of the interim and proposed ramping rates. It is unlikely that ramping-up rates associated with flood control operations would affect listed species, so evaluation criteria were not developed for ramping up.

C.1.7.3.1 Ramping Release Rate 1,000 cfs to 250 cfs

Ramping may occur at higher or lower streamflow conditions during the winter and spring runoff periods as part of flood control operations. When the reservoir release is between 1,000 cfs to 250 cfs, the guideline for the ramping rate is 250 cfs/hr.

Evaluation criteria and scoring for ramping in the 1,000 cfs to 250 cfs flow range (Table C-36) are based on Hunter's (1992) guidelines and the interim ramping rates established by USACE in consultation with NOAA Fisheries and CDFG. The highest score is given if stage changes meet Hunter's (1992) guidelines, 0.16 foot/hr during periods when juveniles are present. Ramping that exceeds Hunter's (1992) guidelines by up to 100 percent, receive a score of 4. Ramping activities that exceed Hunter's guidelines by more than 100 percent but still meet the established ramping rate (250 cfs/hr) receive a score of 3. Ramping rates that exceed the interim flow criteria by up to 50 percent (i.e., up to 375 cfs/hr) receive a score of 2, and if ramping rates exceed the interim flow criteria by more than 50 percent (greater than 375 cfs/hr), the score is 1.

Table C-36 Ramping Evaluation Criteria for Streamflows 1,000 cfs to 250 cfs

Category Score	Evaluation Criteria Category
5	Meets 0.16-foot maximum stage change.
4	Within 100% of 0.16-foot criterion (0.32 foot/hr) for stage change.
3	Meets 250 cfs/hr ramping criterion.
2	Exceeds ramping criteria up to 50% (375 cfs/hr).
1	Exceeds ramping criteria by greater than 50% (>375 cfs/hr).

To determine if the ramping rates meet, or the extent to which they exceed the criteria in Table C-36, stage-discharge relationships were obtained from HEC-RAS modeling for the appropriate cross-sections. The HEC-RAS model provides information on the change in stage (depth) associated with a change in discharge. The model itself does not account for the effects of attenuation of releases by flow contributions from downstream tributaries or accretion in baseflow. Therefore, the HEC-RAS model may overestimate changes in stage for progressively downstream cross-sections. Pools, side-channels, and gravel bars attenuate the ramping rate by storing water from higher flows and releasing the water gradually. The largest actual changes in stage are expected closest to the dam.

On Dry Creek, the ramping evaluation includes a 1.5-mile-long reach below Warm Springs Dam. Ten cross-sections (103 to 112) were used in the assessment. On the mainstem Russian River, four cross-sections (48, 48.1, 49, 49.1) closest to Coyote Valley Dam, from approximately 3 miles to 5 miles downstream of the dam, were used. There are no cross-sections available for the East Fork Russian River (cross-section data were collected at two locations on the East Fork near Coyote Valley Dam in May 2000 by SCWA, but these cross-sections have not been used in the HEC-RAS modeling). Therefore, an evaluation of stage-discharge relationships relative to Hunter's guidelines could not be performed. However, flow release data at both dams were examined from recent years (1997 to 1999) to determine the extent to which flood control operations may be meeting the interim ramping criteria as designated in Table C-36.

C.1.7.3.2 Ramping Release Rate 250 cfs to 0 cfs

Ramping of release flows in the range of 250 cfs to 0 cfs typically take place in winter or spring as flood control operations reduce flows from much higher rates following storm events. Flows at the Ukiah gage, above the Forks on the mainstem Russian River, are usually greater than 500 cfs when flood control operations are ramping at release rates less than 250 cfs. During most of the year, juvenile salmonids are expected to be present, and therefore the criteria for juveniles applies (0.16 foot/hr). The evaluation criteria (Table C-37) are similar to that presented for the release rates 1,000 cfs to 250 cfs, except that the interim flow guidelines call for a maximum ramping rate of 125 cfs/hr when reservoir releases are within the 250 cfs to 0 cfs range (USACE 1998a,b). Proposed maximum ramping rates for this flow range is 25 cfs/hr.

Table C-37 Ramping Evaluation Criteria for Streamflows 250 cfs to 0 cfs

Category Score	Evaluation Criteria Category
5	Meets 0.16 foot/hr maximum stage change
4	Within 100% of 0.16-foot/hr criterion (0.32 foot/hr) for stage change
3	Meets 125 cfs/hr ramping criterion
2	Exceeds 125 cfs/hr ramping criteria up to 50% (188 cfs/hr)
1	Exceeds 125 cfs/hr ramping criteria by greater than 50% (>188 cfs/hr)

The analysis procedure using the HEC-RAS model to determine change in stage at the designated cross-sections is exactly the same as that discussed for the 1,000 cfs to 250 cfs ramping range.

C.1.7.4 ANNUAL AND PERIODIC DAM INSPECTIONS AND MAINTENANCE

C.1.7.4.1 Issues of Concern

Annual and periodic pre-flood inspections take place at both Coyote Valley Dam and Warm Springs Dam. Inspections took place in September 1998 and June 1999. In 2000, dam inspection and maintenance activities took place during May. The 2000 inspection for Coyote Valley Dam was scheduled for May, but during the ramp-down steelhead fry stranding was noted downstream. The inspection was cancelled and performed in October (Eng 2000).

It is unlikely that maintenance inspections for Coyote Valley Dam will occur in the spring except for actions classified as emergency situations. Under baseline conditions, flows were reduced or completely shut down, usually for periods of several hours, to accomplish the inspections. Additionally, flows were reduced or shut down to perform periodic maintenance activities on the dams. Depending on the maintenance activities to be performed, flows were reduced or shut down for periods lasting several hours to 1 day or longer. Ramping rates and reduced streamflow conditions are the two primary issues of concern associated with annual and periodic dam inspections and maintenance.

C.1.7.4.2 Ramping Rates

To perform the annual and periodic dam inspection and maintenance work, ramping-down flow releases is often necessary. In recent years, ramping rates have been determined by consultation between USACE and NOAA Fisheries before each year's annual inspection. In the past, stranding has been documented below Coyote Valley Dam, but not below Warm Springs Dam. These cases are discussed in the next section. At Warm Springs Dam, the ramping rate is typically 25 cfs/hr. At Coyote Valley Dam, the typical ramping rate during inspection activities is 50 cfs/hr. However, at Coyote Valley Dam, the USACE ramp-down rates are done at the smallest increments possible. For the 2001 and 2002 inspections, rates were 30 to 50 cfs for Coyote Valley Dam (ENG 2001; 2002).

Issues of concern relative to ramping rates during pre-flood inspection and maintenance activities are primarily related to stranding and dewatering. Depending on when maintenance and inspection activities take place, ramping may affect both fry and juvenile life-history stages.

C.1.7.4.3 Reduced Streamflows During Inspection and Maintenance

During shut-down or reduction of flow from either dam, stranding and mortality may occur, particularly for fry. A bypass flow of approximately 25 cfs to 28 cfs is usually maintained at Warm Springs Dam during pre-flood inspections. During inspections at Coyote Valley Dam, there is no bypass capability, so flow releases must be completely shut down. However, a small flow is maintained below the dam for up to several hours as the plunge pool and afterbay drain, or if the stilling basin is dewatered for inspection as occurred in June 1999. In 2000, maintenance activities were scheduled in May with the hope that higher streamflows in the mainstem would attenuate effects from flow reductions at Coyote Valley Dam.

Flow contributions on the mainstem below the Forks is always greater in the spring compared with the summer or fall months. Inspection of flow records since 1995 at the Ukiah gage (USGS gage 11461000), located above the Forks, indicates that flow has never been less than 11 cfs. Flows are usually greater than 35 cfs, and may be up to several hundred cfs. In contrast, flows in September at the Ukiah gage are almost always 1 cfs to 2 cfs. Streamflows on the East Fork during maintenance activities were expected to be very low since there was no bypass capability. However, observations during the June 1999 inspection and maintenance indicate that some water depth was maintained in the pools, and a small flow was apparent (although it was not measured) despite flow reductions to 0 cfs at Coyote Valley Dam (Terry Marks, USACE, pers. comm. 2000).

Stranding due to ramping rates or partial dewatering of the channel during scheduled activities at Coyote Valley Dam occurred on the mainstem Russian River below the Forks when maintenance and pre-flood inspections were scheduled in May 2000. With the first decrease in flows from approximately 168 cfs to 118 cfs, over ten salmonids were stranded below the Forks, and the decision was made to abandon the scheduled maintenance at that time (T. Daugherty, NOAA Fisheries pers. comm. 2000). During a scheduled maintenance activity on Dry Creek in May 2000, only a few (eight) steelhead were found stranded by the time the ramp-down was completed (R. Sundermeyer, ENTRIX, pers. comm. 2000).

In October 1997, the emergency water supply pipeline at Warm Springs Dam was repaired and the annual pre-flood inspection performed. A minimum 28 cfs release was maintained from the dam for periods lasting for approximately 8 hours over several days in order to perform the repairs and inspection. Dry Creek was monitored by USACE during this time. The monitoring concluded that there was adequate flow for juvenile salmonids, since no mortalities or stranding were discovered (USACE 1997).

A periodic inspection was conducted at Coyote Valley Dam on September 9, 1998. There were no bypass flows during this inspection. Streamflow was monitored 4 miles downstream from the dam, but flow velocities were too low to measure with a current meter. Discharge was estimated to be less than 30 cfs. Further downstream at Hopland, the USGS gage indicated the discharge was below the rating table (indicating less than 200 cfs) for approximately 7 hours. Some juvenile steelhead were stranded and rescued below the dam on the East Fork to approximately 12,000 feet downstream on the mainstem Russian River below the Forks.

A pre-flood inspection at Coyote Valley Dam was performed on June 10, 1999. Approximately 10 hours were planned to conduct the inspection of the outlet works conduit and stilling basin, but this was cut short by a few hours. Releases from Coyote Valley Dam were below the minimum 25 cfs instream flow requirement for approximately 4 hours. SCWA petitioned the SWRCB for a temporary urgency change in minimum flow requirements, which was approved for this inspection. During the inspection, streamflow at the Ukiah gage (above the Forks) was 12 cfs to 14 cfs, and at Hopland it ranged between 93 cfs to 221 cfs. Although water was pumped out of the stilling basin (contributing approximately 5 cfs downstream), the stilling basin was never dewatered and an inspection of it was cancelled. Direct mortality was a concern due to potential entrainment when pumping the stilling basin. NOAA Fisheries issued an Incidental Take Statement in the Biological Opinion for the maintenance activity and required monitoring of the East Fork Russian River for strandings and temperature (NMFS 1999). No strandings or fish mortalities were found, and there were no significant increases in temperature (Terry Marks, USACE, pers. comm. 2000). During work scheduled at Coyote Valley Dam in October of 2000, as well as September of 2001 and 2002, no stranding or mortality was documented.

C.1.7.4.4 Evaluation Criteria for Ramping During Dam Maintenance and Inspections

Evaluation criteria for ramping during pre-flood inspections are based on the historical incidence of stranding that has been documented at Warm Springs Dam and Coyote Valley Dam. At Coyote Valley Dam, flow reductions of 50 cfs/hr during May have resulted in fish stranding on the mainstem Russian River. Stranding of juvenile steelhead was documented in September 1998 on the lower East Fork and mainstem Russian River.

At Warm Springs Dam, flow reductions of 25 cfs/hr have resulted in very limited stranding of steelhead during May when fry are present. Stream widths in Dry Creek and the upper mainstem below the Forks are similar (100-foot to 150-foot widths), and HEC-RAS modeling indicates similar stage-change relationships for 25 cfs/hr flow reductions. Therefore, one set of ramping criteria has been developed for application to both locations. Evaluation criteria for ramping rates are given in Table C-38. Scoring criteria distinguish times when fry are present and when only juveniles are present.

Table C-38 Evaluation Criteria for Low Reservoir Outflows (250 cfs to 0 cfs)[1] during Dam Maintenance and Pre-Flood Inspection Periods

Change in Flow (cfs/hr)	Score Juvenile	Score Fry
0 – 10	5	5
10 – 20	5	4
20 – 30	4	3
30 – 40	3	2
40 – 50	2	1
> 50	1	0

1 Only during maintenance activities do releases approach 0 cfs. Bypass flows of 25 cfs would be provided during maintenance.

The evaluation criteria in Table C-38 are appropriate only for those streamflow conditions when there is relatively low flow contribution below the Forks on the mainstem. Ramping during flood control operations occur when streamflows are much higher on the mainstem, typically 500 cfs or more at the Ukiah gage. Under these streamflow conditions, there are no exposed channel bars on the mainstem or the East Fork, and stranding is much less likely. Therefore, ramping evaluation criteria appropriate for assessing potential stranding are those previously defined in Table C-38 for flows between 250 cfs to 0 cfs.

Evaluation criteria listed in Table C-38 should be used when streamflows are less than 500 cfs at the Ukiah gage. Stage-discharge relationship information generated by the HEC-RAS model was used as an independent check to identify how the flow ranges in the evaluation criteria compare with Hunter’s criteria. Stage changes associated with 25 cfs/hr reductions at Warm Springs Dam and both 50 cfs/hr and 25 cfs/hr at Coyote Valley Dam were modeled.

Warm Springs Dam

Stage changes associated with 25 cfs/hr incremental flow reductions beginning at 250 cfs, then 225 cfs, 200 cfs, 175 cfs, 150 cfs, 125 cfs, 100 cfs, and 75 cfs are shown for ten cross-sections on Dry Creek in Figure C-2. The change in stage associated with a given streamflow is shown by the height of each bar. For example, the bar on the x-axis at 250 cfs for cross-section 103 represents a flow reduction from 250 cfs to 225 cfs, and the associated stage change is indicated on the y-axis as less than 0.08 foot. A bar for cross-section 103 representing a flow reduction from 225 to 200 cfs, and the associated stage change indicated on the y-axis is a little greater than the change at 250 to 225 cfs. Transect 112 is closest to Warm Springs Dam, and transect 103 is the most distant. Overall, the stage change associated with 25 cfs/hr ramping meets the 0.16 foot/hr Hunter criteria within most of the flow ranges below 250 cfs.

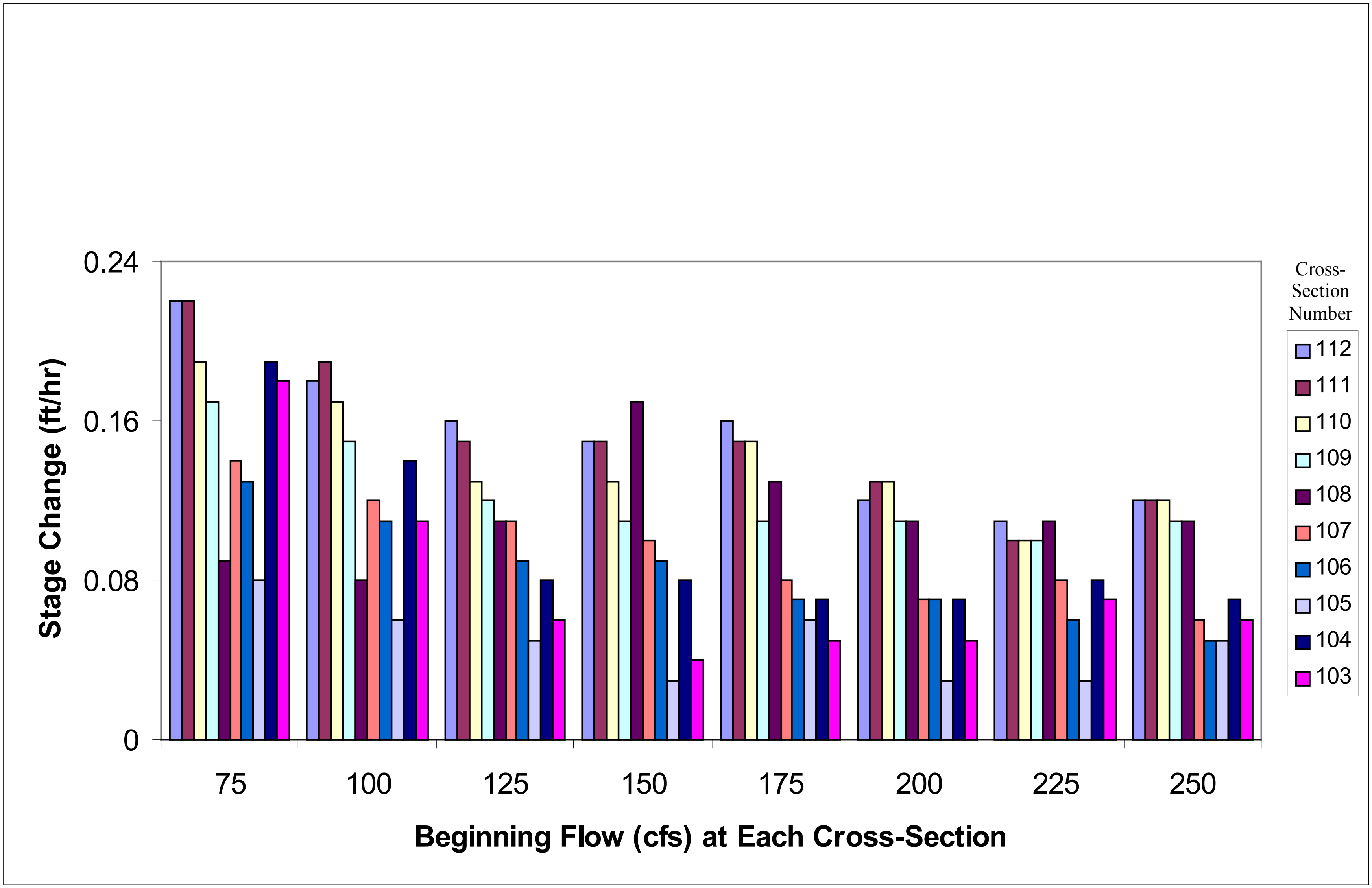

Figure C-2 Stage Changes Associated with 25 cfs/hr Ramping Rate at Warm Springs Dam

Russian River and East Fork below Coyote Valley Dam

Stage changes associated with 25 cfs/hr incremental flow reductions beginning at 250 cfs, then 225 cfs, 200 cfs, 175 cfs, 150 cfs, 125 cfs, 100 cfs, 75 cfs, and 50 cfs are shown for four cross-sections on the mainstem Russian River below the Forks in Figure C-3. Cross-section 49.1 is closest to the dam (approximately 2.5 miles downstream), and cross-section 48 is furthest from the dam (approximately 5 miles downstream). The change in stage associated with a given streamflow is shown by the height of each bar. Cross-section data for the East Fork Russian River have recently been obtained, but stage discharge relationships from HEC-RAS modeling were not developed for this analysis. Stage changes associated with 50 cfs/hr incremental flow reductions are shown in Figure C-4.

At 25 cfs/hr reductions, the 0.16 foot/hr criterion is met at most flow intervals in all four of the cross-sections for flow ranges below 250 cfs. At 50 cfs/hr reductions, the 0.16 foot/hr criterion is exceeded, and stage changes are generally in the range of 0.24 to 0.32. This suggests that the potential for stranding is greater at Coyote Valley Dam.

C.1.7.5 INFLATABLE DAM

An inflatable dam is deployed on the Russian River upstream of the Mirabel area. The dam is raised when river flows are declining (generally in the spring) and is lowered when river flows are rising (approximately once or twice per year). Flow recessions during dam inflation or deflation have the potential to result in juvenile fish stranding. Three sets of evaluation criteria were developed based on rate of stage change, habitat features, and frequency of flow reductions.

Hunter's criteria, as well observations on fish stranding downstream of Coyote Valley Dam and Warm Springs Dam, were used to develop criteria to evaluate the effects of the rate of stage change. During inspection and maintenance activities scheduled in the spring at Coyote Valley Dam, 50 cfs/hr reductions in flow have resulted in significant stranding of juvenile fish in the mainstem below the Forks. Results of HEC-RAS hydraulic modeling of the mainstem Russian River below the Forks presented in *Interim Report 1* (ENTRIX, Inc. 2000) indicate that 25 cfs/hr flow reductions would result in stage changes that meet Hunter's 0.16 foot/hr stage-change criterion for most flow intervals. Only limited stranding of fry occurred in Dry Creek (May 2000) when releases from Warm Springs Dam were ramped down at a rate of 25 cfs/hr. Stage-discharge relationship information generated by the HEC-RAS model on cross-sections below Dry Creek indicates that the ramping rate of 25 cfs/hr meets the 0.16 foot/hr Hunter criterion within most of the flow ranges below 250 cfs (ENTRIX, Inc. 2000).

These observations on fish stranding and results of hydraulic modeling suggest that the Hunter 0.16 foot/hr stage-change criterion may be protective for juvenile salmon in the Russian River watershed. Because fry are more vulnerable to flow recessions than other life-history stages of salmon, a more stringent evaluation criterion of 0.08 foot/hr is applied.

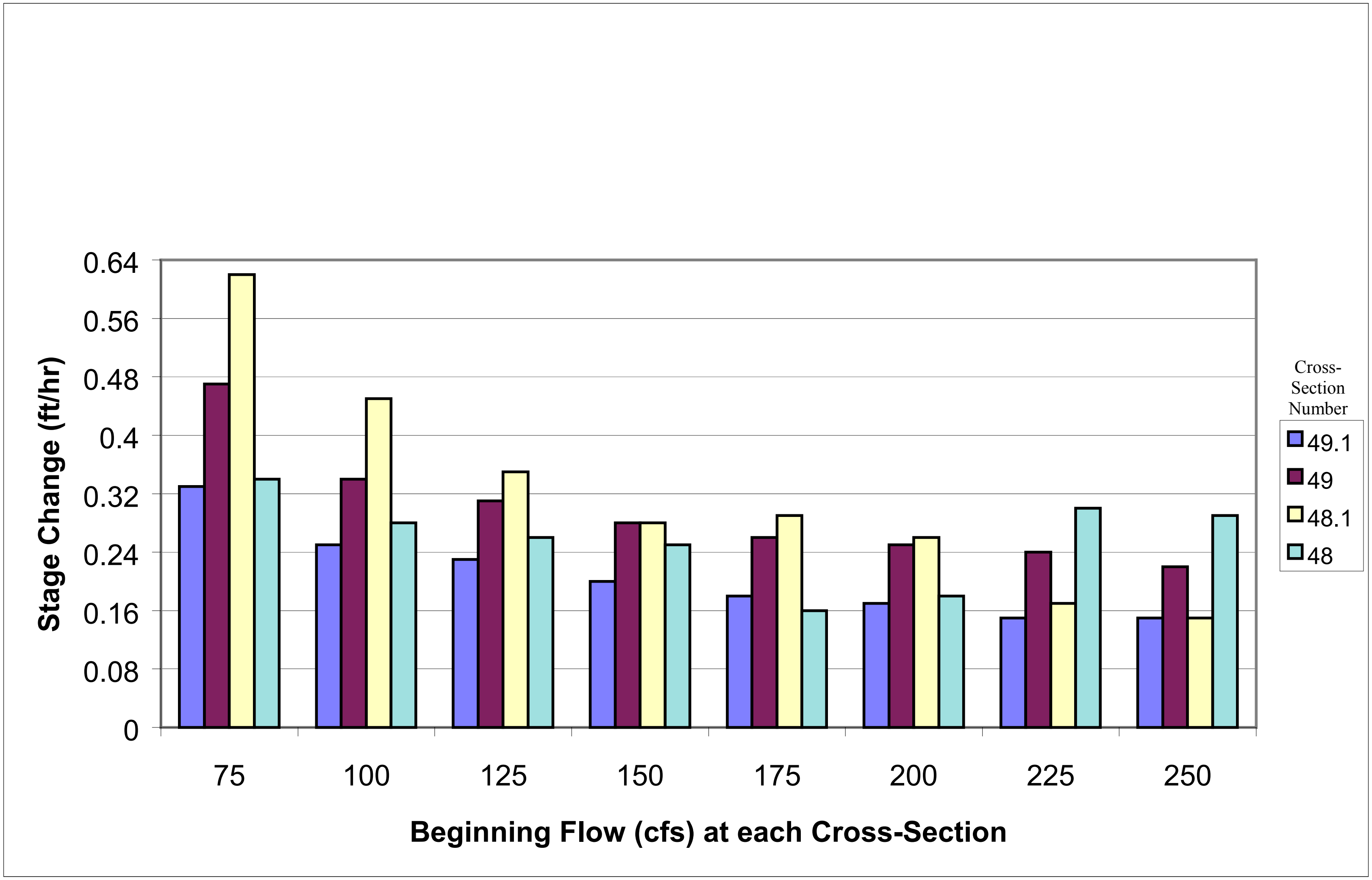

Figure C-3 Stage Changes Associated with 25 cfs/hr Ramping Rate on Mainstem Russian River below Coyote Valley Dam

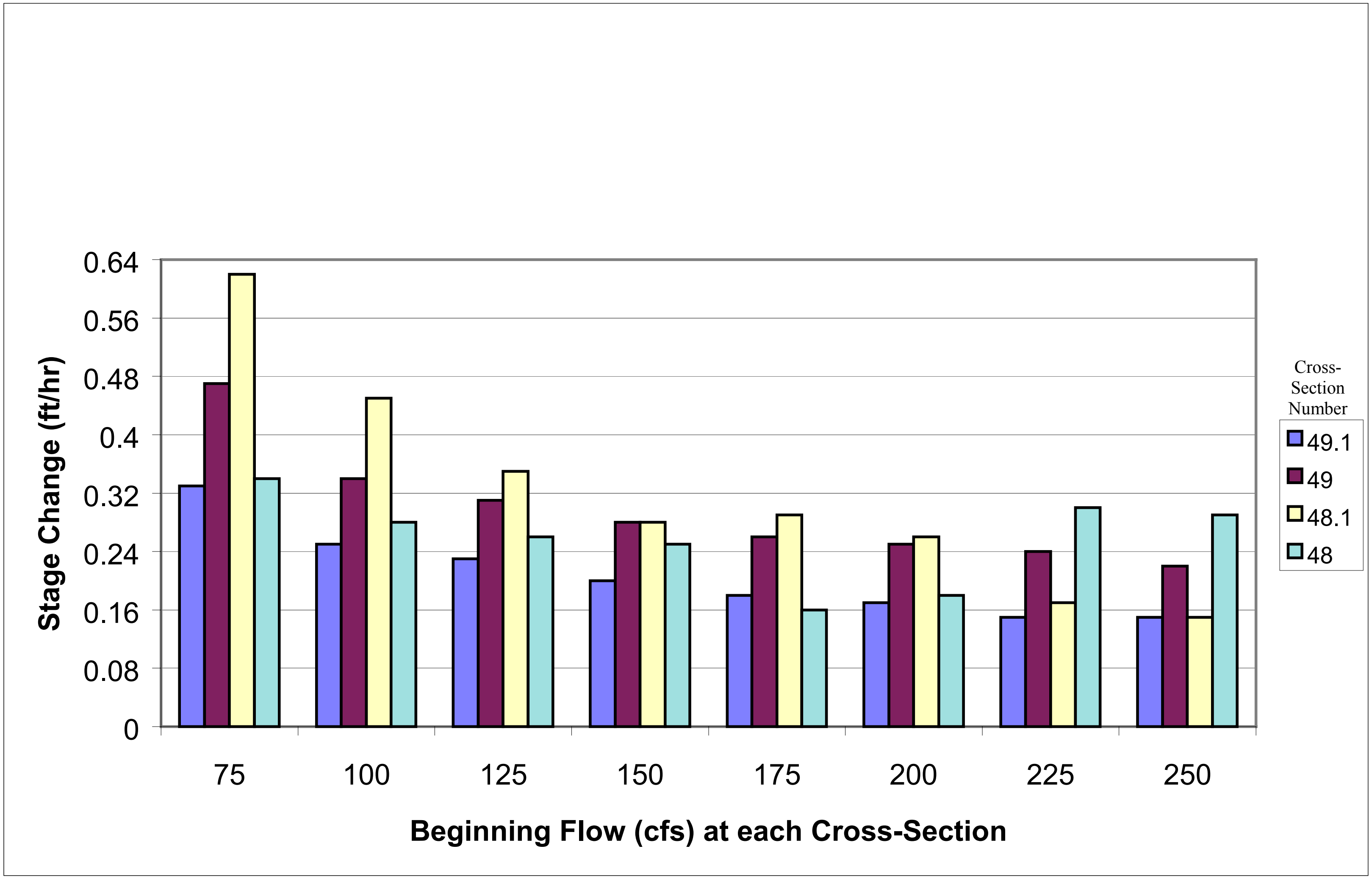

Figure C-4 Stage Changes Associated with 50 cfs/hr Reductions in Flow at Cross-Sections in Mainstem Russian River below Coyote Valley Dam

USACE, in consultation with NOAA Fisheries and CDFG, developed interim guidelines for release changes during flood control operations to protect spawning gravel and juvenile salmonids in Dry Creek and the Russian River. These criteria are less stringent than the Hunter criteria, but are appropriate to use when river flows are high. The dam is generally inflated or deflated when rising river flows are expected. These criteria are therefore appropriate for intermediate scores for this evaluation when the inflatable dam is inflated or deflated. The channel of the mainstem Russian River at Mirabel is larger than it is near Coyote Valley Dam or in Dry Creek, and therefore an equivalent flow change at Mirabel would result in a smaller stage change in this river reach.

At high river flows, the river is generally wetted from bank to bank and therefore the risk of stranding would be low. When flows are lower, riffles may be subject to dewatering and side pools may become isolated. Therefore the risk of stranding would be higher. A conservative estimate of flows below which dewatering may occur is 500 cfs. Stage changes below 500 cfs should be lower than above that level to protect salmonids.

USACE criteria designate three ramping rates determined by river flow. This evaluation uses the mid-flow category, which is for a river flow between 250 cfs and 1,000 cfs. The ramping criterion for these flow conditions is a maximum rate change of 250 cfs/hour. To estimate the stage change that is related to the interim ramping criteria at the inflatable dam, two cross-sections in the impounded area are used to correlate change in water elevation to a 250-cfs flow difference. Using HEC-RAS modeling, a 250-cfs flow change behind the inflatable dam is estimated at approximately a 0.32-foot stage-change.

Evaluation criteria were developed to address the rate of stage change according to lifestage. For juvenile salmonids, the Hunter criterion of 0.16 foot/hr is given a score of 5 (Table C-39). A score of 4, 3, and 2 are assigned to stage-change rates of the inflatable dam of 0.32 foot/hr, 0.48 foot/hr, and 1.4 feet/hr, respectively (based on USACE criteria). Because fry are more vulnerable, evaluation criteria for fry are more stringent than for juveniles. For fry, a score of 5 is assigned to stage-change rates of 0.08 foot/hr (Table C-40). A similar reduction in stage-change rate is used to assign the remaining score criteria.

Habitat features can affect stranding during flow recessions. The risk of stranding for a given reduction in flow increases with low-gradient river channel configuration, presence of long side channels, larger substrate type, and frequency of flow reductions. A river channel with many side channels, potholes, and low-gradient gravel bars has a greater incidence of stranding than a river confined to a single channel with steep banks (Bauersfeld 1978, Beck Associates 1989, and Hunter 1992). Most documented observations of stranding have occurred on gravel and vegetation (Becker et al. 1981 and Satterthwaite 1987).

Evaluation criteria were developed for habitat features that affect the risk of stranding during flow recessions. A single, steep-sided channel with fine substrate and no instream vegetation or potholes is likely to present no risk. The presence of side channels, low-gradient banks, gravel bars, potholes, or instream vegetation would increase the risk. A large area with many habitat features that are likely to induce stranding would have a greater risk than a smaller area with fewer of these habitat features. A score of 5 is assigned if local habitat conditions are unlikely to induce stranding during flow recessions. A score of 0 is given if more than 30 percent of the area of the habitat contain features that are likely to induce stranding (Table C-41).

Salmonids may have developed local adaptations to the frequency of naturally occurring flow recessions. However, an increase in the frequency of flow-reduction events provides additional opportunities for stranding or displacement of juvenile salmonids. Frequent fluctuations, such as daily fluctuation associated with hydroelectric project peaking operations in other river basins, provide much more opportunity for stranding than an occasional event such as a flow reduction after a seasonal flood. A score of 5 is assigned when the frequency of flow reductions due to deflation of the inflatable dam is less than two times a year. A score of 0 is assigned when reductions in flow occur daily (Table C-42).

Table C-39 Stage-Change Evaluation Criteria for Dam Inflation and Deflation for Juvenile and Adult Salmonids

Category Score	Evaluation Criteria Category
5	Meets 0.16 foot/hr maximum stage change.
4	Meets 0.32 foot/hr maximum stage change.
3	Meets 0.48 foot/hr maximum stage change.
2	Meets 1.4 feet/hr maximum stage change.
1	Greater than 1.4 feet/hr maximum stage change.

Table C-40 Stage Change Evaluation Criteria for Dam Inflation and Deflation for Fry

Category Score	Evaluation Criteria Category
5	Meets 0.08 foot/hr maximum stage change.
4	Meets 0.16 foot/hr maximum stage change.
3	Meets 0.32 foot/hr maximum stage change.
2	Meets 0.48 foot/hr maximum stage change.
1	Greater than 0.48 foot/hr maximum stage change.

Table C-41 Habitat/Flow Recession Interaction Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category
5	Habitat features unlikely to induce stranding.
4	Few habitat features present to induce stranding.
3	Some habitat features that induce stranding, but area affected is small (<30%).
2	Many habitat features that induce stranding, but area affected is small (<30%).
1	Some habitat features that induce stranding, area affected is large (>30%).
0	Many habitat features that induce stranding, area affected is large (>30%).

Table C-42 Flow-Reduction Frequency Evaluation Criteria for Fry, Juvenile, and Adult Salmonids

Category Score	Evaluation Criteria Category
5	Less than 2 fluctuations per year in critical habitat.
4	Between 3 and 9 fluctuations per year in critical habitat.
3	Between 10 and 29 fluctuations per year in critical habitat.
2	Between 30 and 100 fluctuations per year in critical habitat.
1	More than 100 fluctuations per year in critical habitat.
0	Daily fluctuations in critical habitat.

C.1.8 Criteria for Construction, Maintenance, and Operation Activities

Direct effects from construction, operation, and maintenance activities may occur during water supply, channel maintenance, or restoration activities. These effects include fine sediment input to the stream, short-term increased turbidity, and direct injury or mortality of fish. Vegetation removal activities may have immediate and direct effects associated with the use of herbicides or mechanical removal methods, and indirect effects to habitat related to changes in instream habitat or the amount and quality of the riparian corridor. Channel maintenance activities such as streambank and streambed stabilization, sediment maintenance, debris removal, and vegetation control have potential long-term effects on salmonid habitat.

C.1.8.1 Fine Sediment and Turbidity

Activities that take place within a stream or on the streambanks may increase sediment input to the stream. By implementing effective best management practices (BMPs) during construction or maintenance activities, effects may be minimized.

Maintenance or construction activities can affect salmonids or their habitat in the immediate work area or in nearby areas downstream of the activity. If activities take place when no life-history stage for the species is present, then no negative short-term effect would be expected. If a construction or maintenance activity takes place during the low-flow period in the summer and fall seasons, potential direct, short-term effects would be restricted to juvenile salmonids and their rearing habitat, and some limited steelhead and Chinook salmon migration.

Evaluation criteria for sediment control address two components: instream and upslope sediment control (Table C-43). For the first component, instream sediment control, a high score indicates instream work practices with the highest degree of sediment containment, and a low score indicates poor or no sediment containment measures. Working in a stream that is dry receives a score of 5. Rerouting streamflow from the construction area into a clean bypass, or other method that reroutes streamflow, isolates the construction area and prevents sediment input to the stream; therefore, these options are given a fairly high score of 4. A clean bypass is routing streamflow around the maintenance activity so that continuity of flow and water quality is maintained downstream. A clean bypass isolates the work area from the wetted stream channel. For instream work in a wetted channel that does not use a bypass, there is a greater potential for sedimentation downstream, unless other effective methods of controlling sedimentation are used. For example, SCWA typically uses a gravel berm downstream to filter turbid waters and reduce potential sedimentation. Such effective sediment control measures are given a moderate score of 3. Limited sediment control is a measure that is only partially effective, and that may allow significant turbidity and sedimentation. Limited sediment control measures receive a score of 2, and no instream sediment control measures in wetted channels receive the lowest score of 1.

A second component of sediment control is identified as upslope sediment control. Depending on the site-specific characteristics, upslope sediment control may include either streambanks that are immediately adjacent to the channel, or in some cases, may include more distant upland areas where erosion control measures are employed. This component evaluates the amount of disturbance, the effectiveness of erosion control measures, and whether bank stabilization is improved or degraded. Similar to the instream component, a high score indicates minimal or no slope disturbance and a low score indicates maintenance activities that are likely to cause slope failure or bank erosion, with resulting sediment input.

Table C-43 Sediment Containment Evaluation Criteria

Category Score	Evaluation Criteria Category
	Component 1: Instream Sediment Control
5	Project area does not require rerouting streamflow.
4	Clean bypass or similar method used.
3	Effective instream sediment control (e.g., berm/fence).
2	Limited sediment control.
1	No instream sediment control.

Table C-43 Sediment Containment Evaluation Criteria (Continued)

Category Score	Evaluation Criteria Category
	Component 2: Upslope Sediment Control
5	No upslope disturbance, or an increase in upslope stability.
4	Limited disturbance with effective erosion control measures.
3	Moderate to high level of disturbance with effective erosion control measures.
2	Action likely to increase sediment input into stream.
1	Action likely to result in slope failure, bank erosion, an uncontrolled sediment input to the channel, or major changes in channel morphology.

C.1.8.2 EVALUATION CRITERIA FOR INJURY TO FISH

Work in a streambed that has flowing water or standing pools may result in direct injury or mortality to fish or incubating eggs. Furthermore, displaced fish may be subjected to short-term stress, predation, or competition.

Immediate effects from construction or maintenance activities are scored according to the opportunity for injury to protected species (Table C-44). BMPs are generally implemented to reduce the risk of injury to fish and may include scheduling the work when protected species are not present or when the stream channel is dry, conducting a biological survey of the project area to assess appropriate BMPs, isolating the project area from streamflow, and providing escape or rescue for fish that may be present. Site-specific factors dictate appropriate BMPs. For example, isolating a construction or maintenance area from streamflow may be a preferred alternative for some projects. However, this may result in an unacceptable disruption of habitat for other activities, such as activities that take place in a long reach of stream but involve minimal instream work. While a fish rescue may reduce the risk of injury, it has its own risks associated with it, and there may be times when providing escape is a preferred alternative.

High scores are associated with activities that have a low risk of injury, such as those that do not take place in the channel or that take place in a dry channel. Some activities require almost no interaction with the stream channel or water in the stream. These include maintenance activities related to road maintenance and scour holes around culverts. If activities take place when no fish species are present, then no direct injury to fish would be expected. The greater the interaction with the stream, the higher the risk of direct mortality to fish and effects associated with increased turbidity and sedimentation of aquatic habitat. Occasionally, a project may require equipment in the flowing channel. Appropriate BMPs, such as project area surveys by a qualified biologist, isolation of the project area from flow, and fish rescue or escape, reduce the potential for direct injury from equipment or due to stranding.

The lowest scores are given to activities that occur in a wetted channel where appropriate BMPs are not applied or applied in a limited way. There may be site-specific considerations that limit the ability of staff to apply appropriate BMPs. For example, emergency work after a landslide may restrict the ability of staff to implement all practices that might be desirable.

Table C-44 Opportunity for Injury Evaluation Criteria

Category Score	Evaluation Criteria Category
5	Project area is above the high-flow WSE defined by the 1.5 year bankfull event and/or above the tops of bars, and requires no isolation from flow.
4	Project area is within dry part of channel, or construction and maintenance activity scheduled when species of concern are not present.
3	Appropriate BMPs are applied; e.g., project area survey, escape, or rescue provided, project area isolated from flow (if appropriate).
2	Limited ability to apply appropriate BMPs.
1	Appropriate BMPs are not applied.

The risk to protected fish species may be greater if there are sensitive biological or habitat conditions in a particular area. For example, if a maintenance activity is scheduled in the late summer in the upper mainstem Russian River, where important rearing habitat is known to occur, the effects may be more significant than if the work were performed in the Mirabel area where high summer water temperatures may limit the number of listed fish species present. The level of risk is qualified and described where there is a general knowledge of the tributary or channel reach conditions where the work is performed.

C.1.8.3 DIRECT EFFECTS OF VEGETATION CONTROL

Vegetation may be removed from streambanks and stream-channel bottoms to maximize channel flow capacity and to reduce the risk of fires. Non-native vegetation removal may be conducted as part of a restoration action. Herbicides can have direct effects on fish habitat.

Other vegetation control methods such as hand-trimming or mechanized mowing are primarily related to indirect, long-term habitat alteration effects (although immediate effects may also occur upon implementation). The indirect effects associated with vegetation maintenance activities are discussed in Section C.1.8.4.

C.1.8.3.1 Direct Effects Related to Herbicide Use

Spraying herbicides to control vegetation in channels can have an immediate direct effect on fish and water quality. Herbicides have been developed to minimize effects in riparian and wetland habitats. For some plants, such as the highly invasive, non-native weed *Arundo donax* (Giant Reed), a combination of mechanical/hand-clearing and herbicide use are effective, while the use of one or the other alone is not. An herbicide approved for aquatic use should be used near streams. For example, a commonly used herbicide that has been approved by the EPA for use near aquatic areas is glyphosate (Rodeo®).

Glyphosate, when used according to directions, is practically nontoxic to fish and may be slightly toxic to aquatic invertebrates (EXTOXNET 1996).

C.1.8.3.2 Evaluation Criteria for Vegetation Control Associated with Herbicide Use

Vegetation control evaluation criteria (Table C-45) assess the amount and quality of chemicals released into the aquatic environment when herbicides are used. Higher scores are associated with practices that use only an aquatic contact herbicide, and limit herbicide use to smaller, targeted areas. Herbicide application can be limited with the use of an individual backpack unit as opposed to being broadcast over a wider area, or it can be applied over a large area with aerial spraying. Moderate to heavy herbicide use is associated with large-scale vegetation removal activities; for example, if a large infestation of *Arundo* had to be removed.

Table C-45 Evaluation Criteria for Vegetation Control Associated with Herbicide Use

Category Score	Evaluation Criteria Category
5	No chemical release.
4	Limited use of herbicide approved for aquatic use in riparian zones or over water.
3	Moderate to heavy use of herbicide approved for aquatic use in riparian zones or over water.
2	Use of herbicide not consistent with instructions.
1	Use of herbicide not approved for aquatic use in riparian zones or over water.

C.1.8.4 INDIRECT EFFECTS OF VEGETATION CONTROL

Vegetation control methods include removal by hand-trimming or mechanized mowing, or spraying, and indirectly by excavation of sediments and gravel bars. Another indirect method of vegetation control is to plant desirable native riparian vegetation that will exclude the establishment of non-native or undesired vegetation.

The duration of potential effects of vegetation removal may be short if vegetation grows back quickly, or long-term if vegetation is restored over a long time (for example, it takes years for trees to reestablish). However, effects of vegetation removal can be far more complex.

Riparian vegetation has several important functions for the quality of fish habitat (Meehan 1991). Water quality, including temperature and suspended sediment concentrations, may be influenced. Riparian vegetation, especially trees, provide canopy cover and shade, and removal may increase solar input and result in higher water temperatures in the summer. Loss of riparian vegetation may have a greater effect on temperature on narrow streams than on wide streams where the canopy covers only a small portion of the channel. Since salmonids occupy a wide variety of habitat types during various life-history stages, it is important to have quality habitat in small and large streams. On small streams, grasses and shrubs may be sufficient to provide beneficial effects, while on larger streams, shrubs and trees may be more effective.

Over the long-term, trees contribute to habitat diversity, often by creating high-quality pools or high-flow refuge habitat when they fall into the channel. This process of tree recruitment may help to control the slope and stability of the channel, particularly in forested regions (Beschta and Platts 1986). Instream vegetation such as willows can help stabilize gravel bars and provide high-flow refuge habitat. Streambank stability is also maintained and water quality improved by flexible vegetation such as willows and grasses. During floods, water transports large amounts of sediment in the stream. Vegetation mats on the streambank reduce water velocity, causing sediment to settle out and become part of the bank, increasing nutrients that are so important to productive riparian vegetation. Root systems of grasses and other plants can trap sediment to help rebuild damaged banks. Riparian vegetation provides cover, an important determinant of fish biomass. Well-sodded banks tend to gradually erode, creating undercuts important as refuge habitat.

Riparian vegetation provides a basis for food production. Vegetation provides habitat for terrestrial insects, which are an important food for salmonids. Plant matter provides organic material to the stream, essential for production of aquatic insects. This organic input is especially important to narrow, heavily shaded, headwater streams that support an aquatic insect community known as “shredders,” which in turn supports salmonids. In sunnier, wider streams, an insect community known as “grazers” is supported by algal growth. Where cover and stream temperatures are not limiting, additional sunlight after limited vegetation removal may benefit primary productivity.

Vegetation removal can be beneficial if it involves the removal of non-native noxious species. Non-native vegetation, such as the invasive *Arundo donax*, can negatively alter critical habitat of salmonids, including alterations to the food web, the amount and quality of riparian and instream cover, streambank stability, and alterations to flow regimes. Replacement of non-native species with native species generally will help restore a naturally functioning, native, riparian ecosystem.

Separate evaluation criteria for vegetation control were developed for constructed flood control channels and natural channels. Constructed flood control channels are widened and straightened waterways that have been significantly altered and improved based on flood control criteria. The purpose of the improvements is to increase hydraulic capacity.

C.1.8.4.1 Vegetation Control and Removal in Constructed Flood Control Channels

Riparian vegetation is essential for building and maintaining stream structure and for buffering the stream from incoming sediments and pollutants. On natural channels when bank vegetation is reduced, flood events are more likely to accelerate changes in channel morphology such as widening or incision. However, constructed flood control channels are designed to be stable with minimal bank protection associated with riparian vegetation. As part of the design criteria, if flood velocities were calculated to exceed 6 fps, then hard-armoring was installed to protect sections of the bank from erosion

(SCWA 1983). Thus, under baseline conditions, removal of riparian vegetation on streambanks (except grass banks that are maintained) was anticipated to be an ongoing maintenance activity to preserve the channel design flood capacity.

Evaluation criteria for vegetation control are based on the extent of removal of native riparian vegetation (Table C-46). Higher scores are associated with activities that preserve or increase a riparian corridor composed of native species. Lower scores are given for maintenance practices that result in removal of riparian vegetation. The greater the extent of removal, the lower the score. Removal of invasive, non-native vegetation could have a beneficial effect because this may allow native riparian vegetation to establish.

For maintenance activities that include only selective removal of vegetation along access roads and between the access roads and fencelines, or for removal of non-native species, the highest score, 5, is given. The category score of 5 also includes “spot” or site-specific treatments that may require vegetation removal over very small distances, typically near structures such as culverts or at bridge crossings.

For maintenance activities that require more than selective removal of vegetation to keep access roads open, and thereby result in removal of vegetation across up to 25 percent of the cross-sectional area of the channel, the score is 4. When more than 25 percent and up to 50 percent of the cross-sectional area of vegetation is removed, then the score is 3. Removal of more than 50 percent and up to 75 percent of the vegetation represented in the cross-sectional area of the channel receives a score of 2, and more than 75 percent removal results in the lowest score, 1.

Table C-46 Vegetation Control Evaluation Criteria for Flood Control Channels

Category Score	Evaluation Criteria Category
5	No removal except selectively along access roads, fencelines, “spot” treatments, or to remove non-native species.
4	< 25% reduction in vegetation.
3	>25% to < 50% reduction in vegetation.
2	>50% to <75% reduction in vegetation.
1	>75% reduction in vegetation.

Consideration is also given to the life-history stage of listed species that are likely to be utilizing channels subject to vegetation maintenance and to the quality of habitat available. For example, if listed species are primarily using a flood control channel for migration rather than for rearing or spawning, the effect of vegetation loss is not considered to be as significant. If more than one life-history stage is potentially affected, the loss of vegetation becomes more significant. These considerations are addressed in conjunction with the scoring criteria listed above.

C.1.8.4.2 Vegetation Removal in Natural Channels

Constructed flood control channels are designed to be stable without the influence of riparian vegetation. Unlike the constructed flood control channels, riparian vegetation has an important effect on bank strength and stability in natural channels. Bank erosion and lateral channel migration contribute sediments to the stream if protective vegetation and root systems are removed from streambanks. Loss of vegetation decreases bedform roughness, thereby increasing velocities which may reduce the potential for sediment deposition on the channel margins or on the bank. Riparian vegetation provides cover, an important determinant of fish biomass. Additionally, well-sodded banks gradually erode, creating undercuts important as refuge habitat. Root systems of grasses and other plants can trap sediment to help rebuild damaged banks.

The potential for recruitment of trees and other large woody debris is probably much greater in natural channels compared with constructed flood control channels. This is due to the stable design and lack of lateral channel migration associated with the flood control channels. Meandering and lateral channel migration is often part of the natural channel processes that will cause bank erosion and tree recruitment. Therefore, removal of riparian vegetation in natural channels likely represents a greater loss of potential recruitment of large woody debris and resulting habitat diversity.

Natural channels tend to provide rearing and spawning habitat, in addition to migration, that most flood control channels do not provide. Therefore, vegetation maintenance activities in natural channels have a greater potential for altering habitat conditions that support multiple life-history stages. On this basis, greater weighting is given to habitat alteration effects resulting from vegetation removal in natural channels than in constructed flood control channels.

Evaluation criteria for vegetation control is similar to that for flood control channels, and is based on the extent of removal of native riparian vegetation (Table C-47). The scoring is slightly different in that there is no removal of vegetation associated with access roads or fencelines on natural channels (category score 5), and the percent of vegetation removal allotted within each of the scoring categories is lower than for flood control channels.

Table C-47 Vegetation Control Evaluation Criteria for Natural Channels

Category Score	Evaluation Criteria Category
5	No vegetation removal except "spot" treatment, or removal of only non-native species.
4	<10% reduction in vegetation.
3	>10% to <25% reduction in vegetation.
2	>25% to <50% reduction in vegetation.
1	>50% reduction in vegetation.

In conjunction with these scoring criteria, consideration is also given to the typical lengths of channel that are subject to vegetation maintenance. Maintenance practices that remove vegetation over long channel reaches are more likely to result in significant change to habitat conditions than shorter channel reaches. For example, complete removal of vegetation (100 percent) in the cross-sectional area over a 25-foot length of channel downstream of a culvert outfall (i.e., "spot" treatment) does not have the same degree of habitat-altering effects as 50 percent removal over a distance of 5,000 linear feet.

These criteria assess the amount of vegetation removed within a site. While limited vegetation removal in isolated sites may not negatively affect salmonid habitat, if the work is done over several sections of a stream and/or in prime spawning and rearing habitat, the net effect may be larger. For example, if willows are removed from several gravel bars to reduce streambank erosion in an important coho salmon stream, the net effect may be to significantly alter channel morphology, the amount of instream cover, and the availability of winter refugia from high flows. To avoid significant effects to salmonid habitat, vegetation removal in natural channels should be kept to a minimum and used only where there is an unacceptable threat from a 100-year-flood event or where a decrease in bank stabilization threatens a structure or property. Alternative solutions should be pursued where feasible. These include bioengineering practices to stabilize banks, tree planting to add bank stability and reduce understory growth, offsetting levees to increase floodplain, or digging floodplain level culverts to increase floodplain draining at culvert crossings.

C.1.8.5 STREAMBANK AND STREAMBED STABILIZATION

Activities are conducted to maintain existing bank stabilization structures in Dry Creek and the mainstem Russian River. Bank stabilization activities are proposed for the mainstem of the Russian River. Bank stabilization activities may also be conducted occasionally in natural channels in response to a catastrophic bank erosion event at the request of a landowner.

C.1.8.5.1 Maintenance of Streambank Stabilization Structures and Levees

Streambanks have been stabilized on Dry Creek and the mainstem Russian River using gravel revetments, steel jacks, sheet-pile, trees, and other materials. Levees are maintained to reduce bank erosion and flooding. On Dry Creek, concrete sills have been installed to provide grade control, preventing streambed incision and resulting accelerated streambank erosion. SCWA maintains these structures.

Potential effects related to maintenance of streambank stabilization projects may be both positive and negative. Positive effects are associated with reduction or prevention of erosion and resulting sedimentation in the channel. Negative effects may be associated with loss of riparian shading and increased water temperatures. Bank stabilization techniques may reduce the complexity of instream cover naturally provided by undercut banks, and exposed root wads. Additionally, the recruitment of spawning gravels, which are often supplied by natural bank erosion processes, may be impeded by bank stabilization structures. Streambed stabilization structures installed on Dry Creek are intended to reduce channel head-cutting and resulting streambank erosion.

Information is not available to quantify effects due to maintenance activities. Qualitative evaluation of these effects is based on the extent to which maintenance of bank stabilization structures reduce overstory canopy cover (shading), in-channel cover (undercut banks, exposed root wads, backwater areas), and gravel recruitment. The greater the loss of these habitat elements (in comparison with what normally could be supported by the stream reach), the greater the effect.

C.1.8.5.2 Bank Stabilization in the Russian River

Bank stabilization activities are conducted by the MCRRFCD and SCWA in the Russian River mainstem. Bank erosion occurs when flow is directed into the riverbank by large gravel bars that are often well-vegetated. Under the proposed project, gravel bars would be graded and overflow channels would be created at sites where the formation or growth of gravel bars is likely to cause bank erosion. The work would be conducted in site-specific areas to direct the river channel away from susceptible banks. Protocols would be implemented to reduce the potential for negative effects on salmonid habitat. This maintenance activity is closely linked to vegetation maintenance practices, which is also intended to ensure channel flood-capacity and to control bank erosion. The procedure for gravel bar grading and sediment removal conjunctively removes willows and other riparian vegetation from the bars. Since gravel bar grading is closely interrelated with removal of riparian vegetation growing on the bars, there is an associated loss of shade and canopy cover.

These bank stabilization activities in the Russian River are likely to affect the geomorphology of the channel. If stable bar development is prevented, the channel becomes straightened and sinuosity decreases. Decreased sinuosity reduces bank erosion, but also reduces the opportunity for pool development by limiting scour on the outside of meander bends. In addition, gravel bar grading generally results in a flatter streambed, reducing the hydraulic diversity and associated aquatic habitat diversity represented in the channel. This lack of hydraulic diversity probably includes reduced availability of high-flow refuge habitat due to limited bedform topography as bars are regularly graded.

Evaluation criteria for gravel bar grading in the Russian River are based on the relative amount of material removed and/or graded from the bar in the vertical dimension. The more material that is removed from bar above the thalweg, the greater the potential effects. Grading protocols that leave a greater percentage of the bar height intact will have smaller effects. By maintaining as much of the bar form as possible, alteration of channel morphology and hydraulics are reduced, including minimizing changes to width-depth ratio, sinuosity, roughness, sediment transport, velocity, and overall habitat complexity. This is consistent with the recent NOAA Fisheries guidelines for evaluating sediment removal (NOAA Fisheries 2003).

The proposed gravel bar grading procedures for the Russian River call for a post-graded bar that is at least 1.5 feet higher than the elevation of the low-flow channel, in order to maintain a thalweg. Additional procedures for maintaining a vegetated buffer strip adjacent to the low-flow channel and for grading the bar to prevent stranding are described in Section 4.4.

NOAA Fisheries (2003) guidelines suggest that an approach based on effective discharge to define the limits of gravel extraction from bars should be used in order to minimize harmful effects associated with gravel bar grading. This method is based on the concept that removal of bar material above the water surface elevation defined by the effective discharge (i.e., the flow that, over the long-term, transports the most sediment in the channel) represents the least potential harm. Bar material removed below the stage corresponding to the effective discharge represents a potentially greater harm to geomorphic and fish habitat conditions.

To address bank erosion problems, SCWA would conduct gravel bar grading activities in the Russian River in Sonoma County, and MCRRFCD would conduct these activities along a 36-mile reach of the Russian River. Defining the effective discharge at any given location, and the corresponding stage at a given bar cross-section site is not practical for evaluation purposes in this BA. Stage-discharge relationships are different at any particular site along the longitudinal profile of the river. The effective discharge also changes as the mainstem gains flows from major tributaries. Therefore, the evaluation criteria presented in this analysis is based on a more simplified approach that considers the relative percentage of the bar height that is likely to be removed (Table C-48).

Table C-48 Evaluation Criteria for Gravel Bar Grading in the Russian River

Category Score	Evaluation Criteria Category
5	No sediment removal or grading.
4	<25% of the bar height is removed.
3	25% to 50% of the bar height is removed.
2	>50% to 75% of the bar height is removed.
1	>75% of the bar height is removed.

As an example application of the criteria, assume that the maximum bar height is 6 feet above the adjacent thalweg and SCWA removes 4.5 feet of the bar height, leaving 1.5 feet above the thalweg. The score would be 2 ($4.5 \div 6.0 = 0.75$ or 75 percent).

In addition to the scoring criteria associated with bar height, a qualitative assessment is applied that considers the anticipated linear extent and frequency of maintenance actions, protocols implemented, and observations of existing aquatic habitat and geomorphic conditions.

The bar height scoring criteria are not applied to sediment maintenance activities in constructed flood control channels. Although there are similarities between sediment transport, channel hydraulics, and fluvial processes in the constructed flood control channels with natural channels, there are some important differences. A critical difference is that the width-depth ratio, entrenchment ratio, sinuosity, and sometimes gradient have been significantly altered from natural conditions in order to provide flood capacity. Therefore, the stage-discharge relationships associated with the "effective discharge" of an essentially permanently altered channel form is much different than the original natural channel form. Most of the geomorphic characteristics (dimension and planform) of the flood control channels are non-adjustable, and were purposely designed this way in order to ensure flood capacity.

C.1.8.5.3 Natural Channels

SCWA would, under certain site-specific catastrophic conditions, remove sediments in natural channels in the Russian River basin, including the Russian River. This sediment removal is usually done in conjunction with bank stabilization work. The range of activities associated with bank stabilization and sediment removal include levee repair, vegetation removal, and channel realignment where bars are directing high flows into unstable streambanks. Potential long-term habitat-altering effects of sediment and bank stabilization maintenance in natural channels include:

- Reduced canopy cover, increasing water temperatures.
- Reduced recruitment of spawning gravels.
- Change in channel geomorphology, including straightened channel platform that limits development of pool habitat, and overall simplification of habitat complexity.

Evaluation of habitat-altering effects of sediment maintenance activities in natural channels is based on a qualitative assessment that considers the extent and frequency of maintenance actions. Consideration is also given to the type of protections and BMP guidelines built into the SCWA approach for work in natural channels.

C.1.8.6 Sediment Maintenance

Sediments are removed from constructed flood control channels and are redistributed (i.e., bar grading) in natural channels with flood easements to ensure that channel capacity is maintained and to reduce bank erosion. Sediment maintenance takes place in constructed flood control channels. SCWA would not perform routine sediment removal activities in natural waterways. SCWA has hydraulic maintenance easements that are permissive and SCWA would continue to access various natural creeks to remove debris or vegetation to restore hydraulic capacity.

Habitat effects from sediment maintenance activities for listed species may include:

- Increased water temperatures and reduced cover if riparian vegetation is removed or disturbed;
- Reduced supply of spawning gravels;

- Change in channel geomorphology that may result in various habitat effects such as alteration of fish passage conditions, reduced channel sinuosity that limits pool and rearing habitat, and reduced high-flow refuge, and;

- General loss of hydraulic and associated aquatic habitat complexity depending upon the type of habitat conditions normally present in the project reach.

C.1.8.6.1 Flood Control Channels

Almost all sediment removal in Zone 1A[1]-constructed flood control channels is confined to streams draining to Laguna de Santa Rosa near Stony Point Road in the Rohnert Park-Cotati area. The combination of very flat gradients (typically less than 0.002 foot/foot) and high sediment production to the streams result in sediment deposition that reduces channel flood capacity.

Long-term changes to critical habitat for salmonids may occur due to sediment maintenance, but these effects could be either positive or negative. Long-term negative effects include potential reduction in available gravels that are of suitable size for spawning and lack of bed-form features such as bar-pool development that influence fish passage and also provide hydraulic diversity and associated habitat diversity. Long-term positive effects may include a reduction in fine sediment loading to downstream reaches that could improve spawning gravel quality, pool depth, and overall habitat diversity.

Evaluation of sediment removal effects in flood control channels is based on observations of changes in channel geomorphic and habitat conditions prior to and following excavation activities in 2000 and 2001. The status and recent history of sediment excavation for all Zone 1A-flood control channels, as well as ongoing hydraulic assessments, are used to estimate the extent of the work that is likely to be performed.

C.1.8.7 DEBRIS CLEARING

Debris clearing includes the removal of large woody debris, construction debris, and trash (e.g., shopping carts, tires, cars) from the stream channel to improve the flood capacity of the waterway. Equipment is operated from the bank rather than in the channel, so there is little risk for direct fish mortality attributable to debris-clearing activities. Changes to instream habitat may occur when debris is removed. large woody debris may be removed from flood control channels in Zone 1A under certain conditions, and is infrequently removed from natural channels only under catastrophic conditions.

Construction debris and trash may not always be harmful to salmonid habitat, and may even provide some of the only instream shelter available in a degraded urban stream. However, removal of trash or construction debris that can degrade water quality is beneficial. Furthermore, streams that are free of trash and filled with more natural instream cover elements are more aesthetically pleasing, and public clean-up events encourage stewardship of streams by local residents. Therefore, it is assumed that trash

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[1] For a description of SCWA Zones, see Section 1.4.7 of main report.

removal provides a net benefit, and only the effects of large woody debris removal are considered.

Large woody debris can play an important role in the structure and function of fish habitat, particularly in forested regions. In non-forested regions, large woody debris may be nonexistent, or have only a very limited scope of influence on channel and aquatic habitat conditions. Removal of large woody debris can potentially reduce the amount of instream cover, reduce pool frequency and depth, and simplify hydraulic and habitat diversity in the channel. Given the importance of woody debris to salmonid habitat, particularly large woody debris, evaluation criteria specifically address large woody debris removal.

The importance of large woody debris for salmonid habitat and biological productivity has been well-documented. Large woody debris provides cover and habitat diversity for salmonids and substrate for benthic invertebrates that serve as food (Sedell et al. 1984, 1988, Bisson et al. 1987). Large woody debris creates pools and undercut banks for cover, plays an important role in controlling stream channel morphology (Keller and Swanson 1979, Lisle 1986, Sullivan et al. 1987, cited in Hicks et al. 1991), and influences sediment movement, gravel retention, and composition of the biological community (Bisson et al. 1987 and Sullivan et al. 1987, cited in Murphy and Meehan 1991, Bilby and Ward 1989, cited in Flosi et al. 1998). Large woody debris creates hydraulic gradients that increase microhabitat complexity (Forward 1984) and the abundance of salmonids is often linked to the abundance of woody debris, especially in the winter (Bustard and Narver 1975, Tschaplinski and Hartman 1983, Murphy et al. 1986, Hartman and Brown 1987).

CDFG defines large woody debris as a piece of wood having a minimum diameter of 12 inches and a minimum length of 6 feet (Flosi et al. 1998). Root wads must be at least 12 inches in diameter at the base of the trunk but do not have to be six feet long.

Large woody debris may be found in the instream zone (stream channel within bankfull discharge demarcations), or in the recruitment zone. Although researchers have various means of identifying the width of the riparian zone from which large woody debris is recruited, in general terms it is no wider than the average height of the typical tree that borders the channel. Trees that are more distant from the channel than their average height, cannot be readily recruited into the channel as large woody debris. The recruitment zone represents approximately 70 percent of the large woody debris recruitment potential to the stream in natural forested channels (McDade et al. 1990, Forest Ecosystem Management 1993, cited in Flosi et al. 1998) so long-term management of the riparian zone is important. Evaluation criteria associated with vegetation control (Section C.1.8.3) address the extent of vegetation removal in the recruitment zone.

Evaluation criteria are structured to give high scores when large woody debris is not removed or if it is modified in place, but retained in the channel rather than completely removed. Modification, as used in this evaluation, includes cutting and removing a portion of the large woody debris. Alternatively, modification could include reorienting in the stream to prevent bank erosion or anchoring a piece of large woody debris so that it is not unstable. An intermediate score is given for limited removal practices (infrequent, only as necessary for flood control), and low scores when it is removed indiscriminately or entirely, and results in reduction of cover or other habitat functions provided by scour around large woody debris (Table C-49). Because the recruitment of large woody debris to a stream can be infrequent or episodic, even occasional removal of large woody debris has the potential to reduce the availability of high-quality salmonid habitat.

Table C-49 Large Woody Debris Removal

Category Score	Evaluation Criteria Category
5	No large woody debris removal or modification.
4	Large woody debris not removed, but modified.
3	Large woody debris removal limited to only when it poses a flood control hazard; removal does not result in substantial reduction of cover or scour in the area.
2	Large woody debris removal limited, but potentially results in moderate reduction of cover or scour.
1	Complete removal of large woody debris resulting in substantial reduction of cover or scour.

If large woody debris is removed in areas where spawning and rearing is likely to occur in either immediate or downstream areas, the effect would be greater than if large woody debris is removed from stream reaches that primarily function as a migration corridor. However, even in a migration corridor, large woody debris can provide cover and velocity breaks for migrating adults to rest and therefore should be retained as much as possible. In urban areas, the installation of instream structures may provide some of the benefits of large woody debris for migrating or rearing salmonids but still retain sufficient flood control capacity in the stream. Therefore, very infrequent removal of large woody debris may not result in a large reduction of cover or scour elements.
As part of the scoring for activities associated with large woody debris removal, consideration is given to the primary habitat function of the channel where large woody debris is removed.

C.1.9 Criteria Related to Restoration and Conservation Actions

Restoration and conservation measures include actions to protect, restore, improve, or enhance aquatic habitat, riparian systems and stream and river channels, reduce the input of fine sediments to the stream corridors, and reduce water use. These actions could include preservation, restoration, or enhancement of riparian or aquatic habitat conditions and may have direct or indirect benefits to the coho salmon, steelhead, and Chinook salmon life-history stages in the Russian River system.

Direct actions are those that have an immediate response and utilization by a target species for one or more life-history stages. For example, actions that would have a direct benefit would include the addition of spawning gravel or the physical improvement of pool quality. The addition of spawning gravel would result in improved spawning conditions or increased spawning opportunities, and may increase recruitment to young-of-the-year (YOY) life-history stages. Improving pool quality could directly benefit several life-history stages for coho salmon and steelhead, including juvenile rearing, winter habitat conditions for juveniles, and summer low-flow refuge habitat. It could also improve adult holding habitat for all three species. Fish populations could show a rapid response to these actions because they involve direct improvements to the physical habitat in the stream.

An indirect action would require some time before it would be reflected in the fish population. For instance, implementing a sediment control plan in a tributary watershed may require many years before an improvement can be detected in the receiving waters, and it may be many more years before these improvements result in a response in the fish population. Reduction in fine sediment could affect habitat quality for invertebrates, alter the local temperature regime, and/or eventually improve spawning habitat quality. All these actions would result in indirect changes to habitat conditions supporting fish. Typically, indirect benefits are realized in incremental changes over time compared to direct benefits.

C.1.9.1 Evaluation Criteria for Restoration Projects

Planning and prioritization of restoration opportunities is an important component in an effective conservation program. Because financial resources are finite, it is important to maximize the biological benefit of conservation and restoration projects. This can be done by developing and utilizing information about the watershed, coordinating efforts on a basin-wide level, developing partnerships with other stakeholders, and seeking opportunities to bring additional financial or in-kind resources to the program.

An assessment of the biological value of specific SCWA restoration projects is made based on the size of the project, whether habitat or population data suggest the area is important or has the potential to be important for spawning or rearing, and the time-frame for the expected benefit. A qualitative assessment of the biological benefit score is given to each project based on several factors as outlined in Table C-50. Each project is evaluated for each of the target species, and for spawning/incubation, rearing, or migration life-history stages.

Typically, larger projects provide more benefits than smaller projects. The size limit is often constrained by funding sources, permitting issues, and the amount of work that can be accomplished in a single working season.

The conservation action is also qualitatively assessed based on the expected duration of the action and the time-frame to full development. The importance of short duration actions are considered to be lower than those with a 1-year to 3-year life span, and both are lower than actions that endure for more than 3 years. An additional time-frame to consider in evaluating the project is the time it takes the project to become fully functional at an ecological level. How long a project takes to become fully functional depends on the type of project. For example, the addition of spawning gravel to a system where spawning sites are limited can have an immediate and dramatic benefit. In contrast, it may take 10 to 20 years for the effects of a riparian restoration program to mature to the point where it begins to benefit the target species. Construction actions are typically evaluated without regard to full development time-frames. However, if riparian vegetation growth and development is required prior to full development, time-frames are typically on the order of decades. Projects with rapid start-up times may have a greater beneficial effect.

Table C-50 Components Considered in Determining the Biological Benefit of a Restoration Project

Component	Description
Size	Length of stream affected. Downstream or upstream habitat may also be affected. For example, streambank erosion control is likely to reduce sedimentation of downstream habitat, or installation of fish passage may result in access to miles of upstream spawning and rearing habitat.
Time	The time-frame for expected benefits. Projects with rapid start-up times may have a greater beneficial effect. Some projects may take some time before benefits are fully realized, but if they are of long duration or permanent in nature, substantial benefits can be realized for protected fish species.
Habitat Elements	A qualitative assessment of the habitat elements affected and their relative importance to protected fish species.
Habitat or Population Data	If data are available on population abundance or stream assessments, they are used to assess the relative importance of the project to protected fish species. For example, a fish passage project that provides access to several miles of high-quality spawning and rearing habitat may have more value than instream habitat improvements in an area that is likely to have limited rearing or spawning habitat. If a known limiting factor is addressed, the project is considered to have a higher benefit.
Cost	Limited public and private funds are available for restoration actions. Projects that can deliver the most benefit for these dollars are preferred alternatives.
Education	A project that has an educational component or can serve as a demonstration project may have indirect beneficial effects.

A qualitative assessment is made of project effects on critical habitat, including elements such as canopy cover, instream cover, sediment effects, and bank erosion. Because changes in these elements are difficult to quantify, actual scoring criteria have not been developed for them. If the project addresses a known limiting factor, it would be considered more important. Any stream assessments or population data that have been collected are used to evaluate the current or potential use of the project area by salmonids.

A project that has an educational component or can serve as a demonstration project may have indirect beneficial effects. Because so much of the Russian River watershed is privately owned, landowner cooperation is essential. Demonstration projects serve to educate the public about the advantages of a restoration action and may help alleviate concerns related to work involving endangered or threatened species on private property.

A restoration project may improve the quantity and/or quality of the habitat or it may produce no change. If a conservation action is expected to improve habitat for protected species, it is scored 3 or better (Table C-51). A project that has a very high potential to benefit would be one that improves a large portion of valuable or potentially valuable habitat, preferably with effects that are likely to occur soon and for an extended period of time. Intermediate or small-sized projects may also have high potential to benefit, and are assigned a score of 4. Some projects, while useful, have small, localized benefits but may be located in areas that have less value for salmonid spawning or rearing and are assigned a score of 3. While a particular project may not have a direct benefit within its footprint, it may provide upstream benefits (such as access to spawning habitat) or downstream benefits (such as an improvement in water quality). If a project has little or no benefit but uses limited public financial resources that may be better spent elsewhere, it is assigned a score of 2. A project that is poorly planned or implemented, results in long-term degradation of habitat, or wastes limited financial resources is scored a 1. For example, a large streambank stabilization project that places riprap along a streambank or redistributes gravel bars to protect a landowner's property, but that degrades salmonid habitat, would receive a lower score than a bank stabilization project designed to improve riparian and instream habitat for salmonids.

Table C-51 Biological Benefit Evaluation Criteria for Restoration Actions

Category Score	Evaluation Criteria Category
5	Very high potential to benefit.
4	High potential to benefit.
3	Moderate potential to benefit.
2	No benefit and uses scarce resources.
1	Poorly planned or implemented, degrades habitat.

C.1.9.2 WATERSHED MANAGEMENT PROJECTS

Watershed management projects include three general categories of projects: 1) data collection, 2) demonstration projects, and 3) information coordination and dissemination. Studies that collect data on salmonids and their habitat have indirect effects that may not be quantifiable, but are potentially significant. When conservation activities are coordinated with other agencies, a greater benefit may accrue to protected species and their habitat. Demonstration projects gather and utilize information on methods to meet specific goals and make that information available for application on a wider scale than the immediate project area, possibly on a watershed scale. Public information and public involvement activities may also have unquantifiable but important effects on listed species and their habitat.

C.1.9.3 DATA COLLECTION

In the absence of data, it would be very difficult to protect listed species and their habitat. Studies funded, coordinated, or implemented by SCWA produce information that is essential for effective and cost-efficient restoration and conservation activities.

C.1.9.3.1 Habitat Data

Information that can potentially benefit critical habitat include stream habitat surveys, water quality data, and temperature data. Stream habitat surveys have been conducted throughout the watershed to help identify and prioritize streams that are in need of restoration. Results are summarized in the CDFG 2002 Draft Russian River Basin Fisheries Restoration Plan (CDFG 2002). Water temperature monitoring since 1996 will help identify streams that may provide the best thermal conditions for salmonid rearing. Finally, a baseline reference for water quality has been established in selected streams, and this will be used to determine relative water quality status in other streams.

C.1.9.3.2 Fish Population Data

Insufficient data exist to assess salmonid population trends in the Russian River. A comprehensive population monitoring program developed in conjunction with CDFG and NOAA Fisheries will assess the current status of steelhead and coho salmon, particularly juvenile abundance. Furthermore, the Inflatable Dam/Wohler Pool fish sampling program is producing information on smolt emigration in the late spring. Of particular value has been information about Chinook salmon.

Historically, coho salmon, steelhead, and Chinook salmon from distant watersheds have been planted in the Russian River. Hatchery broodstock, has, until recently, included out-of-basin stocks. Potential genetic effects of out-of-basin transfers are outlined in a benefit/risk analysis developed for the DCFH and CVFF (FishPro and ENTRIX, Inc. 2000). It is probable that many tributaries of the Russian River contain a mixture of native and non-native stocks. Genetic information is being evaluated to determine which streams may contain relatively native genetic strains so that those strains can be targeted for conservation.

C.1.9.3.3 Invasive Plant Species

Non-native plants can alter the riverine ecosystem. When invasive plant species replace native riparian vegetation, alterations can occur to the food web, riparian and instream cover, and general habitat characteristics of the stream. One non-native species on the Russian River is the aforementioned *Arundo donax*.

Arundo is potentially a serious problem for the Russian River ecosystem. It has already established itself in extensive portions of wetland and riparian habitats, especially in southern California. *Arundo* forms tall, dense stands. It propagates vegetatively more so than by seed, and it has deep roots. It quickly invades new areas, particularly where the ground is cleared, when floods break up clumps of *Arundo* and transport rhizomes downstream. Because it outcompetes native species, it may jeopardize riparian restoration projects.

Arundo changes the stream channel by retaining sediments and constricting flow. Root masses that can be more than a meter thick stabilize streambanks and alter flow regimes. *Arundo* provides less canopy cover than native species do, so stream temperatures are increased (Dunne and Leopold 1978, cited in Bell 1997). It changes the quality and timing of organic debris that forms the base of the riparian food chain. It does not seem to provide food or habitat for native species of wildlife, including salmonids. It is highly flammable, and when riparian corridors are changed from flood-defined to fire-defined communities, diverse ecosystems are converted to pure stands of *Arundo* (Bell 1997).

Because *Arundo* has not yet established itself to the devastating degree that it has in southern California, a proactive removal program may still be effective and affordable in the Russian River watershed. It is effectively removed with a combination of manual or mechanical means and herbicide use. Additional treatments may be needed to prevent it from re-establishing itself. As *Arundo* spreads in a downstream direction, eradication has to be coordinated in the watershed. Furthermore, a public information campaign is required, as *Arundo* is sold in nurseries.

While some information about *Arundo* and its control has been developed in southern California, insufficient data exist for northern California streams. Its biology and ecology is not well-studied. The mechanisms with which it overtakes native riparian communities are not well-understood, particularly in cooler northern climates. It is not known what factors may prevent infestation. Distribution and abundance data are lacking. More information is needed to develop effective *Arundo* eradication and prevention programs.

C.1.9.4 DEMONSTRATION PROJECTS

Demonstration projects provide information that can be applied throughout the Russian River watershed to improve conditions for salmonids and their habitat. They include Pierce's Disease control, fish-friendly farming, and the Palmer Road Erosion control.

C.1.9.4.1 Pierce's Disease Control

Pierce's Disease is caused by a bacterium (*Xylella fastidiosa*) that kills grapevines. It is spread by xylem-feeding insects in the sharpshooter family, particularly the glassy-winged sharpshooter. There is no known control for Pierce's Disease. Management focuses on control of the sharpshooter and removal of diseased plants. The most susceptible vines are on the outskirts of grape-growing areas next to pastures or riparian areas.

In the Russian River watershed, vineyards are often located adjacent to riparian zones where the vegetation is prime habitat for sharpshooters. When vineyard owners indiscriminately clear riparian vegetation, valuable riparian corridors can be destroyed. By removing only host plants that attract sharpshooters and leaving others, the insects' abundance can be dramatically reduced. Plants that sharpshooters favor include wild grape, Himalayan blackberry, French broom, and periwinkle. Plants that are not likely to attract sharpshooters include oaks, California bay laurel, alder, maple, ash, and red willows (University of California at Davis 1999).

C.1.9.4.2 Fish-Friendly Farming

Many streams in the Russian River watershed run through agricultural land, particularly vineyards. The success of this voluntary education and certification program depends on the level of participation and implementation by growers. Therefore, incentives that increase participation are important to the success of the program.

C.1.9.4.3 Palmer Road Erosion Control

Roads can cause degradation of streams by modifying natural drainage and accelerating erosion processes, altering channel morphology and by changing the runoff characteristics of watersheds. (Furniss et al. 1991). The resulting sedimentation of streams can be dramatic. Improperly designed roads can affect migration of salmonids. There are guidelines for road siting, building, and maintenance that can help reduce negative effects and minimize sedimentation of streams (Furniss et al. 1991, WDFW 1999, NMFS 2000). A properly designed rural road can provide a demonstration of principles that should be applied throughout the watershed.

C.1.9.5 Evaluation Criteria for Information Value

Some research data may have localized usefulness, such as water quality sampling conducted in specific streams. Other research may be useful to many areas of the river watershed, such as development of effective *Arundo* eradication methods. Evaluation criteria for information gathering or dissemination assess how wide a geographic area the information has the potential to be used in, and a qualitative assessment is made on the relative biological benefit to listed species or designated critical habitat (Table C-52).

Table C-52 Information Value Evaluation Criteria

Category Score	Evaluation Criteria Category
5	Basin-wide applicability.
4	A region or “type” of habitat (i.e., small tributaries or lower mainstem).
3	Isolated project/stream information.
2	Information not useful to protected species or habitat.
1	Incorrect or misleading information.

C.1.9.6 Information Coordination and Dissemination

The Russian River basin will be subjected to increasing demands on its resources. If it is to be protected and restored to the fullest extent possible, coordination among stakeholders is essential. By coordinating with agencies, government entities, and various organizations or watershed groups, limited resources can be put to maximum use. By providing information and training to the public, additional conservation actions can be implemented and future problems can be avoided. Furthermore, some activities, such as *Arundo* control or development and implementation of water quality standards, must be coordinated on a watershed level to be fully effective. While the benefits of these activities are not quantifiable, they are potentially significant.

C.1.10 Fish Production Facility Criteria

The ESA's focus is on natural populations and the ecosystems upon which they depend. However, the ESA recognizes that artificial propagation may be useful for recovery efforts. NOAA Fisheries has noted that (Hard et al. 1992):

> *Artificial propagation of Pacific salmon may be consistent with the purposes of the Endangered Species Act in two situations: 1) when artificial propagation facilitates the recovery of a listed species, or 2) when the enhancement of unlisted populations does not impede the recovery of a listed species or compromise the viability or distinctiveness (and hence be a factor in the listing) of an unlisted species.*

Artificially spawned populations (that may or may not be listed) may affect naturally-spawned populations. NOAA Fisheries notes that deliberations over the use of artificial propagation for recovery must recognize the potential for deleterious direct and indirect effects on the listed species (Hard et al. 1992).

This section identifies potential effects hatcheries may have on listed fish species and their habitat. There are two basic categories of potential effects: 1) effects on water quality, and 2) genetic and ecological effects on protected fish populations. Evaluation criteria are presented that reflect the range of hatchery practices that can affect these factors. It must be emphasized that the identified potential effects are intended to describe hatcheries in general and not the specific operations at the Don Clausen Fish Hatchery (DCFH) and Coyote Valley Fish Facility (CVFF). The evaluation criteria are developed to describe a range of hatchery operating procedures, and as such will describe operations in addition to those currently practiced at the DCFH and CVFF.

C.1.10.1 Water Quality

Operations at most hatchery facilities involve diversion of water into the facility and discharge back to the river. In concentrated fish production processes, waste solids from fish feces and excess feed typically become entrained in the hatchery water supply system. If not treated, the effluent from fish production facilities can affect water quality in the receiving water (the stream) through increased turbidity, settleable solids, biological oxygen demand (BOD), and nutrient loading. Additionally, water temperature in the discharged water can potentially affect salmonid habitat.

Aquatic animal production facilities with more than 20,000 pounds annual production are subject to discharge water quality limits established through the EPA National Pollution Discharge Elimination System (NPDES). For the Russian River area, NPDES permits are administered by the NCRWQCB. The NCRWQCB has established water quality limits for the areas it administers based on designated beneficial uses for the subject waters. In Dry Creek and the Russian River, these beneficial uses include cold-water fish life, which reflects the general water quality standards for the protection of threatened species.

NPDES permits require that the facilities be equipped with waste treatment equipment to insure compliance with specified water quality criteria (Table C-53). Compliance is monitored by sampling the facility effluent two times per month, with results submitted in a monthly report to the NCRWQCB. It is further stipulated that sampling occur during cleaning operations, because this is when poor water quality conditions are most likely to occur.

Table C-53 Discharge Standards for DCFH and CVFF

Parameter	Effluent Limit (Daily Maximum)
Total Suspended Solids	15 mg/l
Total Settleable Solids	0.2 ml/l/hr
pH	within 0.5 of receiving waters
Salinity (chloride)	250 mg/l
Temperature	no measurable change to receiving water
Turbidity	no increase > 20% of background
DO	> 7.0 mg/l
Flow – DCFH	15.5 million gallons/day
Flow – CVFF	7.11 million gallons/day

The discharge permits include stipulations in addition to the monthly monitoring noted above. For example, discharge of wastes from pond cleaning and the bypass of wastes around the pollution control pond are prohibited. At DCFH, it is prohibited to discharge detectable levels of chemicals used for the treatment or control of disease, other than salt (sodium chloride).

Because the NPDES discharge standards reflect general water quality requirements for coho salmon, steelhead, and Chinook salmon, they provide a practical means for assessing potential effects from DCFH and CVFF operations. Evaluation criteria for water quality effects are presented in Table C-54. A score of 5 is given to facilities that are in full compliance with NPDES standards and lower scores are given when routine compliance occurs less frequently.

Discharge standards have not been set for some chemicals used in captive breeding programs. The primary chemicals used are vaccines, antibiotics, chlorine, along with chlorine neutralizer, and salt to address disease concerns. Sex hormones are used to increase development, and anesthesia is typically used whenever captive animals are handled.

Table C-54 Water Quality Compliance Evaluation Criteria

Category Score	Evaluation Criteria Category
5	Continuous compliance with NPDES standards.
4	Compliance with 75 – 99% of standards.
3	Compliance with 50 – 74% of standards.
2	Compliance with 25 – 49% of standards.
1	Compliance with 0 – 24% of standards.

The waste stream of a broodstock program is disinfected once a parasite or contagion is confirmed. Effluent streams flowing from infected stocks can have chlorine gas injected into the outfall flowing from the facility. The chlorine, after adequate time, is then neutralized with sodium thiosulfate. If chlorine injection fails, the waste stream should be shut down.

The DCFH coho salmon captive broodstock program qualifies for NOAA permit exemption for the use of chemotherapeutics through qualification under the Threatened and Endangered Species permit process. However, this applies only to the use of vaccines and treatments on listed salmon and does not exempt the operator from state or federal environmental compliance. Vaccines, antibiotics, disinfectants, and hormones must be removed from the effluent stream. Carbon filtration is the conventional method used.

C.1.10.2 GENETIC AND ECOLOGICAL RISKS

The potential risks of hatchery production on protected fish species can be categorized into two areas: genetic risks and ecological risks. Genetic risks include loss of diversity within and between populations, outbreeding depression, and inbreeding depression. Ecological risks include increased competition for food, habitat or mates; increased predation; disease transfer; altered migration behavior; decreased long-term viability; artificial selection; disproportional survival; and harvest bycatch. Each of these risk factors is described in this section, along with a discussion of the major theoretical and observed effects to wild salmonid populations. There is also discussion of the general hatchery practices and management decisions that may affect each risk factor. Table C-55 is a cross-reference index that associates the various risk factors with hatchery practices.

Stock productivity refers to the mean number of offspring produced per adult that survives to spawn. A stock productivity less than 1.0 means the population is decreasing; greater than 1.0 means it is increasing; and equal to 1.0 means it is stable. For large populations, the stock productivity can be less than 1.0 (declining) for a relatively long time before the population goes extinct. Small populations have less time. Salmon populations are characterized by extreme variation in year-to-year returns, and it is not uncommon for healthy populations occasionally to experience stock productivity less than 1.0 (Flagg et al. 2000). Conversely, a severely depressed population may occasionally experience a year with productively greater than 1.0, only to return to the depressed state the following year.

When stock productivity is consistently less than 1.0, a supplementation program may be implemented as an interim measure to maintain the population until environmental conditions change or anthropogenic effects are corrected. While supplementation may have some negative effects on wild fish, these are preferable to extinction.

Table C-55 Risks to Wild Salmonids from Hatchery Production and Associated Operations That May Contribute to Each Risk

Risks to Wild Salmonids Associated with Hatchery Production	Hatchery Operations That May Contribute to Each Risk[1]						
	Source of Broodstock	Numbers of Broodstock Collected	Broodstock Sampling and Mating	Rearing Techniques	Release Strategies	Duration in Hatchery Captivity	Harvest Management
Genetic Risks							
Loss of Diversity							
Within Population Diversity	X	X	X	X		X	
Between Population Diversity	X				X		
Outbreeding Depression	X		X				
Inbreeding Depression	X	X					
Ecological Risks							
Competition					X		
Predation					X		
Disease Transfer				X			
Outmigration Behavior					X		
Long-Term Viability				X			
Artificial Selection	X			X		X	
Disproportional Survival		X	X				
Harvest Bycatch							X

[1] See next section, C.1.10.3, for discussion.

Supplementation may not be needed for a depressed stock with productivity greater than 1.0, as it should be able to recover on its own. A supplementation program may increase the population size above some critical level more rapidly and therefore accelerate recovery.

The analysis of the hatchery program is conducted in large part following the structure of Waples (1996). First, an overview of genetic and ecological risks is provided. This is followed by a description of evaluation criteria used to assess the level of risk associated with specific hatchery practices.

C.1.10.3 Genetic Risks

C.1.10.3.1 Loss of Diversity

Conservation biologists divide genetic and life-history diversity into two components, diversity within a population and diversity between populations. Within-population diversity is the suite of phenotypes within an interbreeding group of individuals. Between-population diversity is that component of variation that occurs between populations. Both types of variation are widely viewed as crucial contributors to long-term species persistence. Maintenance of within-population diversity is crucial for the continued existence of a given population because it provides the ability to respond to random environmental changes (stochasticity) typically encountered in the local environment. Maintenance of between-population diversity allows the species to inhabit environments with different selective regimes. It is crucial for evolutionary processes that help ensure the long-term survival of the species.

Loss of Within-Population Diversity

Loss of within-population diversity refers to a loss of genetic variability within the composite (hatchery-reared and naturally-spawned) population. Genetic drift (random changes in gene frequencies over time) and inbreeding (which may be a result of small population size within either population component) may reduce within-population genetic variation. Hatchery programs can contribute to the loss of within-population diversity when hatchery broodstock includes only a limited sample of the gene pool available in the naturally spawning population, and when the survival of that component is magnified.

Changes in within-population diversity are primarily influenced by four factors: the selection of broodstock sources; the numbers of broodstock available to both the hatchery-reared and naturally spawning population components; the degree to which the sampling methods represent those spawning aggregates; and the survival of adults and/or juveniles during their period of residency in the hatchery. Specific recommendations for minimizing the potential risk associated with each of these functional areas of hatchery operations are provided.

Loss of Between-Population Diversity

Loss of between-population diversity refers to a reduction in the genetic differences between discrete populations. It should be noted that a reduction in between-population diversity does not necessarily mean there is a reduction of variation within any population (although this may be the case); it merely describes the loss of genetic identity (loss of divergence) between two or more populations. In salmon, the primary natural mechanism leading to a loss in between-population diversity is straying and successful reproduction of fish in non-natal streams.

Anadromous salmonids exhibit a high degree of fidelity to their natal stream when returning as adults to spawn (Quinn et al. 1985). Although approximately 90 percent of spawning adults return to their natal stream, some stray to non-natal streams to reproduce (Grant 1997). Straying is thought to facilitate colonization of new habitat (Unwin and Quinn 1993), maintain genetic diversity within small populations (Grant 1997), and help maintain single populations at risk of extinction (Hill et al. 2002). There is a considerable genetic influence on survival and return of salmon, local fish can have a survival advantage over translocated fish, and population-specific adaptation can occur fairly rapidly (within 30 generations) of establishment of populations into uncolonized habitat (Unwin et al. 2003).

High rates of straying may lead to genetic homogenization, or a decrease in genetic differences between populations (Grant 1997). Straying may reduce the total amount of genetic variability within salmon stocks if it leads to a loss of alleles through genetic drift. Alternately, straying could have a positive influence if it increases the range of heritable phenotypic expression within populations. Whatever the case, management may seek to maintain between-population variability by minimizing straying of hatchery-reared individuals to nontarget populations. Release strategies that may reduce the incidence of straying are discussed in Section C.1.10.5.4.

Stock transfers, the active collection of fish from one population for use as broodstock or for direct outplanting in another population, directly erodes between-population diversity. Rather than maintaining a natural stray rate, stock transfers may constitute a substantial portion of the adult returns in the next generation. If stock transfers are repeated, the target stock may become genetically similar to the source population. As discussed previously, this may not be inherently detrimental. However, adaptations to the local environment, such as age at return or other life-history traits, may be disrupted by too much straying or by stock transfers (Quinn 1984). It is theorized that several populations, each with unique genetic characteristics, may have a greater combined resiliency to environmental change than several genetically identical populations (Cooper and Mangel 1998).

Given that it may be impossible to protect between-population diversity within the Russian River basin, managers should seek to avoid erosion of this variation on a larger geographic scale. To do so, managers should seek to maintain the highest possible degree of homing fidelity for hatchery raised fish released in the Russian River. Straying can be minimized by rearing and acclimating hatchery fish in water from the target stream (Dittman et al. 1994, 1996). Thus, the development of acclimation facilities could reduce the risk of loss of between-population diversity.

C.1.10.3.2 Outbreeding Depression

Outbreeding depression refers to a decrease in fitness following hybridization of individuals with divergent genetic composition. Outbreeding depression may occur due to dysgenic processes (i.e., the breakdown of coadapted gene complexes [epistasis]) or through disruption of genotype-environment interactions (i.e., loss of local adaptation). The source of hatchery broodstock is the primary factor affecting the risk of outbreeding depression. A breeding program that derives broodstock for a target population from its returning adults is unlikely to cause outbreeding depression. However, if programs utilize stock transfers, the risk of outbreeding depression increases as geographic distance and differences in selective regimes between stocks increase.

Intrinsic Coadaptation (Epistasis)

Intrinsic coadaptation, or epistasis, describes traits that rely on interactions between genes/loci (Lynch 1991). Templeton (1986a, 1986b) indicates that coadaptation occurs most readily in species with restricted recombination, a possible result of population subdivision, small population size, and inbreeding. Since salmonids exhibit a strong homing extinct (i.e., return to the natal stream), it is conceivable that populations may develop unique coadaptations resulting in a fitness advantage in the local environment. It follows that introgression by individuals not possessing the same unique coadaptation could disrupt the epistatic interaction and decrease fitness of the progeny. Unfortunately, there are no tests currently available to easily assay the existence or probability of the existence of coadaptations.

The transmission of coadaptations from parent to progeny makes direct measures of coadaptation difficult as well. For example, F_1 (first generation) progeny arising from a cross between an individual possessing a coadaptation and one lacking a coadaptation will inherit the epistatic interaction. However, recombination during gamete formation will likely disrupt the coadaptation, and it will not be passed to the F_2 (second generation) progeny. Therefore, breakdown of epistasis typically will not occur until the F_2 generation, and, to date, few studies have overcome the difficulties of tracking fish through two full generations. Gharret and Smoker (1991) documented a decrease in fitness exhibited by F_2 crosses of even- and odd-year pink salmon. The authors suggest that the decrease in fitness may have resulted from the breakdown of a coadapted gene complex. Unfortunately, the authors did not incorporate sufficient F_2 controls, so their assertion that decreased fitness was the result of disruption of epistasis remains unproven.

Certainly, the life-history characteristics of salmonids suggest that the evolution of population-specific epistatic interactions is possible. However, the inability to assess the existence or assign a probability of occurrence to coadaptation limits management implications to a qualitative discussion. Overall, the probability of outbreeding depression increases with reproductive isolation between the stocks in question. For example, if broodstock is derived from adult returns to the target population, outbreeding depression is almost impossible. However, if broodstock is derived as a stock transfer from a distant population with which natural gene flow is currently and was historically minimal, the probability of outbreeding depression increases.

Extrinsic Coadaptation

In addition to breakdown of coadapted gene complexes, outbreeding depression can occur as a consequence of hybridization between populations that express different karyotypes. Karyotype refers to the number of chromosomes possessed by an individual, while karyotypic race refers to the distribution of karyotypes within a population.

Successful hybridization of salmon with different karyotypes is documented (Kusunoki et al. 1994). For example, Thorgaard (1983) found that coastal stocks of rainbow trout that were indistinguishable morphologically or by allelic frequency, varied in chromosome number from 58 to 64 within and between putative populations. However, while hybridization of karyotypic races occurs, Garcia-Vazquez et al. (1995) suggest that wild fish undergo selection toward a standard karyotype. While outbreeding depression doesn't always occur as a result of hybridization of salmonids with differing karyotypes, management may seek to avoid mixing different karyotypic races of salmonids. In order to avoid mixing karyotypic races, hatchery programs could derive broodstock from the endemic population. Whatever the case, since individuals with differing karyotypes may occur within the same population, it is unclear whether or not outbreeding depression will occur as a result of hybridization between fish with differing karyotypes.

Outbreeding Depression due to Disruption of Local Adaptation

The mechanisms of outbreeding depression discussed previously are dysgenic (strictly genetic) in nature. Outbreeding depression may also occur via disruption of local adaptation. Local adaptation refers to a phenotype (either physical or behavioral) resulting from the complex interaction between a genotype and the environment. An illustration of this type of outbreeding depression is provided by coho salmon hatchery practices in coastal Oregon streams. Broodstock collection proceeded by the capture of fish as they appeared in the river, and continued until broodstock quotas were achieved. The result was selection for the earliest returning adults. Since run-timing is a partially heritable trait, hatchery-reared progeny returned and spawned earlier than the mean return time of the stock prior to hatchery influence (Nickelson et al. 1986). Early spring freshets may have reduced the survival of progeny of early returning fish relative to those returning at the historical peak (Nickelson et al. 1986). Avoiding outbreeding depression as a result of loss or disruption of local adaptation could be achieved by deriving broodstock as a representative sample of the target population.

Because salmonids exhibit a strong homing instinct and exhibit age-structured or overlapping generations, it is possible that populations may develop unique coadaptations, karyotypes, or local adaptations. It follows that a population possessing a unique coadaptation, karyotype, or local adaptation may be negatively affected by introgression from a genetically divergent stock. Therefore, the best mitigation for outbreeding depression is the derivation of broodstock as a representative sample of the target population. Theoretically, supportive breeding following this practice would prohibit mixture of genetically divergent individuals, minimizing the risk of outbreeding depression.

Since genetic divergence requires reproductive isolation or strong differential selection, geographically proximate stocks experiencing similar selective regimes may be more genetically similar than two stocks that are geographically distant and/or subject to different selective pressures. In addition, gene flow in the form of straying is more likely between proximate stocks, which suggests that proximate stocks may be less genetically divergent than geographically distant stocks.

The risk of outbreeding depression as it relates to hatchery operations can be affected by the source of broodstock and by the protocols for broodstock sampling and mating. The anticipated risk of these operations with respect to the proposed Russian River production program alternatives are discussed in Section 5.6.

C.1.10.3.3 Inbreeding Depression

Inbreeding refers to the mating of two closely related individuals; more closely related than any two individuals collected randomly from the population (nonrandom mating). Inbred progeny have a lower heterozygosity (i.e., two alleles at any single locus are more likely to be the same than expected under random mating) than the population as a whole (Tave 1993). For example, progeny of sib-mating (spawning of a brother-sister pair) suffer a mean loss of 25 percent heterozygosity relative to heterozygosity expected from a randomly mating pair (Waldman and McKinnon 1993). Inbreeding results in a reduction in the overall heterozygosity of a population. Inbreeding is not inherently positive or negative, and is frequently used in aquaculture to increase productivity or optimize traits (Shields 1993, Tave 1993, Wangila and Dick 1996).

Inbreeding depression occurs when decreased heterozygosity lowers fitness through loss of heterozygote advantage (heterosis), loss of adaptively advantageous alleles, or by expression of alleles that are deleterious in the homozygous state (dominance) (Allendorf and Leary 1986, Mitton 1993, Lutz 1996 and 1997, Ballou 1997, and David 1997). The effects of inbreeding may vary depending on the demographic history of a population. For example, populations that have experienced serial bottlenecks may not be as susceptible to inbreeding, since deleterious alleles may have been purged during the bottleneck events (Tanaka 1997) and/or there is very little genetic variation left to lose. Recent evidence suggests that inbreeding depression may be exacerbated by fluctuating or stressful environments (Miller 1994). Thus, it is conceivable that environmental perturbations and fluctuating population sizes within the Russian River might promote inbreeding depression.

Within the scientific community, there is little agreement as to the probability or extent of inbreeding depression among fishes. For example, according to Waldman and McKinnon (1993), inbreeding depression has been detected in every fish species for which there are data. However, most of their examples refer to intensive aquaculture programs for which inbreeding may be intentional or the result of poor hatchery management. Therefore, this represents a test of the theory of inbreeding depression, not a test of the likelihood of occurrence in a natural population or a well-managed conservation program. Among salmonids, it has been suggested that residual tetraploid inheritance could limit the potential for deleterious effects of inbreeding. Because of residual tetraploidy, the expression of a deleterious recessive allele would require that an individual be homozygous at all four loci (if the second pair of chromosomes are active) (Waples 1990), or, alternatively, that selectively advantageous alleles are lost at each locus. Regardless, inbreeding in general should be avoided in conservation programs to the extent possible, unless specifically required as a means to maintain unique variation (e.g., half-sib mating strategies).

In the Russian River, the risk of inbreeding depression can be managed to some extent by the selection of broodstock. Populations used for broodstock acquisition could be sampled for genetic diversity and the degree of relatedness expressed within potential founding populations could be used as a means to prioritize sources. Once broodstock is obtained, pairings could be assigned based (in part) on minimum kinship methods (Montgomery et al. 1997). Therefore, the relative degree of risk posed by inbreeding depression can be evaluated based on the implementation of broodstock collection protocols that maximize diversity and employment of minimum kinship methods to formulate spawning matrices.

C.1.10.4 Ecological Risks

C.1.10.4.1 Competition

Competition between hatchery-reared and naturally-spawned population components may occur if resources are limited (e.g., food, shelter, etc.). If the number of hatchery-reared juveniles released into a stream exceeds its carrying capacity, competition may negatively affect naturally-spawned fish. Competition may occur between individuals of the same species (intraspecific competition) or between individuals of different species (interspecific competition). Intraspecific competition in salmonids may be greater because there is greater niche overlap between conspecifics (members of a species) than individuals of different species. However, management attempts to increase the population size of any one of the three listed species may affect the others.

Smolt size and survival are positively related, and this has encouraged hatchery practices that release large smolts. However, the naturally spawning component of the population is likely to have evolved under the ecological conditions (temperature and food) present in a particular watershed. Release of larger hatchery fish may change the competitive pressures on naturally-spawned fish, as well as change the long-term selective pressure by the mere presence of larger conspecifics in the ecosystem over time.

Data to adequately quantify competitive effects for Russian River salmon are lacking. Therefore, evaluation criteria focus on release strategies. Risk aversion techniques provided through release strategies used at other hatchery facilities to reduce competition are discussed.

C.1.10.4.2 Predation

The release of hatchery-reared juveniles can affect production among the naturally spawning population component through direct predation. For example, studies have shown that large hatchery-reared juveniles may consume smaller naturally reared juveniles of the same (Sholes and Hallock 1979) or different species (Cannamela 1992, 1993). Flagg and Nash (1999) suggest only releasing hatchery-reared juveniles that are a similar size to naturally-spawned juveniles as a means of limiting direct predation. If supportive breeding increases the number of adult returns, predation of juveniles of the same or other species may likewise increase. Predation may be an unavoidable consequence of increased population size.

Release strategies may also play an important role in limiting predation. For example, traditional release strategies typically involve the direct release of a large number of hatchery-reared fish in one location at one time. This strategy may result in the attraction or concentration of predators at the site of release. Furthermore, hatchery releases are typically performed during daylight hours, which may make juveniles more vulnerable to visual predators (Flagg and Nash 1999).

Implementing a production goal that produces only smolts and no fingerlings, and further allows the smolts to acclimate and volitionally leave the facility, may result in decreased predation. Fish leaving an acclimation site volitionally may be physiologically prepared for emigration to saltwater, minimizing residence time in the freshwater environment (Pascual et al. 1995). This has the dual benefit of minimizing predation of the hatchery-reared fish by freshwater predators, and minimizing predation of freshwater fish by hatchery-reared juveniles (Flagg and Nash 1999). There is also evidence that territorial aggressiveness decreases with the onset of smoltification (Iwata 1996).

Evaluation criteria for predation are based on the risk-aversion techniques provided through release strategies used at other hatchery facilities to reduce predation.

C.1.10.4.3 Disease Transfer

Biological pathogens, which are the causative agent of a disease, are an integral part of the environment of all animals, including both wild and cultured fish populations. A NOAA Fisheries review of the ecological impacts of hatcheries (Flagg et al. 2000), indicates that almost all pathogenic microorganisms existed in wild fish populations before the introduction of hatcheries. Since the hatchery environment has a greater potential for higher rearing densities and stress than the natural environment, hatchery populations may be a reservoir for infectious agents. However, there is little evidence to suggest that disease transmission to wild stocks is either routine or significant.

Infectious agents may also be transmitted from fish to other fish through intermediate hosts. Examples of this process include the oligocheate worm, *Tubifex tubifex*, which is responsible for whirling disease, and birds, which can spread pathogens through their feces after ingestion of infected fish (Flagg et al. 2000).

Policies have been developed to prevent the spread of pathogens that might result in the release of seriously infected salmon from hatcheries. These policies are discussed in the rearing techniques discussion of the evaluation criteria section.

C.1.10.4.4 Outmigration Behavior

The “pied piper effect” refers to the downstream schooling of wild fish influenced by large numbers of downstream migrant hatchery fish. It has been reported by scuba divers, but there is little documentation regarding the frequency or condition of its occurrence. There are no quantitative studies of the effects of such behavior on survival of Pacific salmon species or on differential survival between hatchery and wild fish (Flagg et al. 2000). Studies of hatchery-reared Atlantic salmon recorded a smolt-to-adult survival (SAR) of 6.8 percent when fish were released to streams during peaks of smolt outmigration, whereas the SAR was only 2.6 percent for fish released during the troughs, suggesting a possible benefit of the schooling phenomenon (Flagg et al. 2000).

C.1.10.4.5 Long-Term Viability

There are concerns over the long-term viability of reintroduced or hatchery supplemented stocks (Meffe 1992). As noted previously, the interaction of wild-spawned and hatchery-reared individuals is unpredictable. However, experimental evidence suggests that post-release survival of hatchery-reared fish may be low. Reisenbichler and McIntyre (1977) suggest that survival of juvenile steelhead to emigration was higher among wild-spawned fish than their hatchery-reared conspecifics. In addition, Skaala et al. (1996) found that hybrid (hatchery-reared x wild) brown trout smolts had significantly lower survival than wild smolts. The authors employed a visual marker that confounded the results, as it may have increased predation of the hybrids. However, despite a 4:1 hatchery-reared to wild ratio, the genetic contribution of spawning hatchery-reared individuals was only 19.2 and 16.3 percent in two streams (Skaala et al. 1996). It should be noted, however, that parents of the hatchery-reared individuals were collected in a mountain lake and may therefore have lacked some adaptation to the riverine environment. Lane et al. (1990) found that emigration survival of hatchery-reared pink salmon smolts was only 0.4 percent compared to 1.4 percent for smolts of wild origin. Currens et al. (1997) and Williams et al. (1997) found that rainbow trout introduced to the Deschutes and Metolius rivers were derived from a coastal stock that lacked resistance to infection by *Ceratomyxa shasta* in contrast to the native stock. The authors indicate that the lack of resistance resulted in exclusion of introduced fish from areas occupied by the parasite. However, this is a contentious study, as there is some question as to the actual degree of resistance exhibited by the native and introduced stocks. Leider et al. (1990) found that introduced steelhead suffered lower survival probabilities at all lifestages than did the wild stock. Finally, Bachman (1984) found that the behavior of hatchery-reared brown trout was less efficient than wild conspecifics.

Examples of successful introductions or supplementation programs suggest that hatchery-reared fish may be successful under natural conditions. For example, Quinn et al. (1998) and Kinnison et al. (1998) reported on the results of a single introduction of Chinook salmon to New Zealand. The transplanted stock has successfully radiated into resident and migratory life histories, with possible divergence in run-timing among the anadromous stock. In addition, Clifford et al. (1998) found that farm-raised Atlantic salmon were successful in completing their life-cycle and breeding with wild conspecifics.

Unfortunately, many studies assessing the performance of hatchery-reared fish lack the data necessary to determine the factors resulting in success or failure of supplementation or reintroduction. In fact, most available data are from studies of traditional rather than supplementation hatchery programs. In addition, data are lacking to determine if wild-spawned progeny of hatchery-reared parents suffer a competitive disadvantage. These data are crucial for objective assessment of the long-term viability of supplemented populations.

When possible, supplementation programs should seek to obtain broodstock locally to avoid outbreeding depression and to take advantage of regional adaptations that may exist. In addition, it should be clear that supplementation programs cannot succeed in creating naturally sustaining populations unless the factor(s) responsible for the initial population decline are addressed. Documented examples of supplementation programs that addressed both of these principles were not found. Research is currently underway in the Pacific Northwest, but it will take time before these questions are answered.

C.1.10.4.6 Artificial Selection

Artificial selection refers to changes in genetic, behavioral, or phenotypic attributes resulting from rearing in an unnatural environment. As it pertains to hatcheries, artificial selection refers to selection for or against specific phenotypes (the expression of genetic variation as mediated by the environment) of broodstock and/or their progeny during residence in the hatchery. Domestication refers to the end-product of extreme artificial selection, typically requiring several generations, after which the cultured organisms have been altered genetically and behaviorally to the point that they are optimally suited only for the hatchery environment. Both processes result from either relaxation of natural selection in the hatchery environment and/or selection for phenotypes that are adaptive in the hatchery. For example, for a female of a given size, there is a tradeoff between the number and size of eggs that can be produced for a given energy allotment. Under natural conditions, fewer but larger eggs may be preferable, since the increased yolk reserve may provide a survival advantage to the progeny. Alternatively, in the hatchery, egg size may be irrelevant (within reason), since the eggs and juveniles are reared in a less stressful environment. Under such conditions, the relaxation of artificial selection in the hatchery could increase the prevalence of females with smaller, but more numerous eggs, since they would produce a relatively larger number of offspring, who themselves may exhibit decreased egg size. If this trait were to become a dominant feature among hatchery origin females, it is possible that hatchery-reared females would become less successful at reproducing in the wild relative to naturally-spawned females that produce larger eggs. Such a result is termed “domestication.” In general, artificial selection is viewed as a negative side effect of hatcheries, since selection (either deliberate or inadvertent) for phenotypes of greater value in the hatchery environment may decrease the prevalence of phenotypes that are more useful under natural conditions.

Artificial selection that is deliberate, such as selection for larger females for use as broodstock, is largely avoidable. However, artificial selection can be incidental. For example, culling eggs or juveniles exhibiting a high titer for bacterial kidney disease may result in inadvertent selection against those individuals possessing a natural resistance to the disease. In such a situation, practicing artificial selection may be preferable, since the alternative might be a massive horizontal transmission of a deadly disease. In addition, artificial selection can be directional or dispersive; that is, hatchery-rearing may consistently select for a median phenotype, or stochastically select throughout the range of a given reaction norm.

In general, the risks associated with artificial selection are governed by the magnitude of the selective gradient between the hatchery environment and the stream, the heritability of traits subject to artificial selection, and the period of residence in the artificial environment. All things being equal, if the magnitude of the selective differential between the hatchery and natural environment is large and directional, phenotypic divergence between hatchery-reared and naturally-spawned fish may occur rapidly. For example, run-timing among hatchery-reared fish can be dramatically and rapidly altered by selecting broodstock from the earliest adult returns. This occurs because managers can exert strong selection for early return by excluding later returning adults. However, the selection differential can be expected to result in lasting phenotypic divergence only if there is a heritable component of genetic variation governing the expression of the trait. Measures of heritability vary greatly by trait. Age of spawning is heritable to a degree of approximately 90 percent (Tave 1993), while smolt survival is approximately 1 percent heritable (Withler et al. 1987). For salmonids, the mean heritability of 264 traits listed by Tave (1993) is 27 percent. Therefore, for an average trait, approximately 73 percent of the expression (or phenotype) is governed by the environment. In terms of hatchery management, this means that even with 100 percent selection for a given trait (e.g., run-timing), one can expect approximately a 27 percent change in the location of the mean phenotype (e.g., a 27 percent shift toward earlier run-timing) per generation. All things being equal, one would expect the number of diverged traits, and the magnitude of divergence to increase with the duration of captivity. Simply stated, with a longer period of duration, more life-history stages may be subjected to artificial selection, and more traits may become susceptible to the effects of artificial selection. Finally, the accumulation of phenotypic divergence is related to the duration of artificial selection. That is, multiple artificial selection events will almost certainly have a greater effect than single events. For example, for programs that derive broodstock from hatchery-reared adult returns, the risk of serious accumulation of artificially selected phenotypes is greater than for programs that derive broodstock from naturally-spawned adult returns.

As it relates to artificial production, the risks of artificial selection can be minimized (though likely not completely avoided) by: 1) decreasing the selective gradient between the hatchery and natural environment; 2) minimizing the residence time of adults and or progeny in the hatchery environment; and 3) minimizing repeated artificial selection. These strategies are discussed in greater detail in the evaluation criteria sections relating to rearing techniques, duration in hatchery captivity, and source of broodstock, respectively.

C.1.10.4.7 Disproportional Survival

It has been suggested that increased survival of hatchery-reared fish results in a disproportional representation of the genomes of hatchery-reared parents (Leary et al. 1993). It is further theorized that disproportional representation decreases the effective population size of the hatchery-reared and target population (Leary et al. 1993). It is likely true that parental genomes incorporated in hatchery programs are represented disproportionately in the target stocks because the goal of supplementation programs is to increase egg-to-smolt survival. However, if the gene pool of the hatchery-reared component is indistinguishable from the naturally reared component, disproportional representation will have no detrimental effect. Whatever the case, decreases in effective population size due to disproportional survival of hatchery-reared fish may occur in two ways: unrepresentative broodstock collection, or disproportionate family contribution.

Hatchery-reared fish enjoy a survival advantage from egg-to-smolt transformation compared to wild-spawned conspecifics. Therefore, the progeny of hatchery-reared fish will likely contribute more adult returns in subsequent generations than progeny of a wild stock of similar size (assuming that the smolt-to-adult return is equivalent between groups). If the hatchery-reared component of a supplemented population is not genetically and behaviorally representative of the target population (unrepresentative broodstock collection), allelic frequencies may shift, or changes in life-history traits may occur. Therefore, it is crucial that broodstock collection is conducted such that the genetic, physical, and behavioral characteristics of the wild population are represented among the broodstock. This is a difficult task, however, there are examples of success. For example, the captive broodstock for the winter-run Chinook salmon program at Bodega Bay Marine Lab was representative of the wild stock, and supplementation has had positive effects on the effective population size of the wild population component (Arkush et al. 1997). If a population is large, random selection of broodstock across the adult return may be sufficient to ensure a representative broodstock. However, as population sizes decrease, the probability of selecting related individuals increases, and methods to determine descent (such as pedigree analysis) may become necessary.

A second factor contributing to decreased effective population size among hatchery-reared and naturally-spawned components is variance in family size. Variance in family size can occur through several mechanisms. For example, it is well-established that egg fertility varies among individual females. It follows that females with higher fertility may contribute more adults in subsequent generations if smolt-to-adult return is constant among progeny of all females. However, recent research indicates that even in naturally reproducing populations, variability in reproductive success is inherently extreme and only partially genetically based. For example, stochastic environmental events may favor individuals spawning at certain times in one year and at different times in subsequent years. The result is that in natural systems, a few individuals may give rise to a disproportionate number of offspring to represent the next generation (Laikre et al. 1998, Li and Hedgecock 1998). If hatcheries derive a representative broodstock yearly from the target population, the resulting increase in fitness of the hatchery-reared individuals may not be an added variance component beyond what would be observed by natural spawning. Further, if a hatchery broodstock is representative of the wild population it will be supplementing, the effects of variable reproductive success can be partially mitigated by equalizing the number of progeny released from each family (Allendorf 1993). Particularly in small populations, this practice would only reduce the effective population size if all naturally spawning individuals experienced similar levels of reproductive success. Overall, with proper management, increased survival among the hatchery component of a supplemented population should not be deleterious.

C.1.10.4.8 Harvest Bycatch

Overexploitation of naturally-spawned adults may occur when fisheries are targeted toward more abundant hatchery-reared adults. Obviously, where harvest is prohibited, the probability of overexploitation is minimal; however, when harvest is condoned, overexploitation may occur through direct harvest, or incidental mortality. If harvest is permitted, the probability of overexploitation is greater if quotas are based on the absolute number of returning adults rather than the number of naturally-spawned returning adults. While overexploitation may still occur, visually marking hatchery-reared progeny allows managers to target hatchery-reared adults in the fishery by allowing retention of only marked fish.

C.1.10.5 Evaluation Criteria for Genetic and Ecological Risks

In the previous sections, genetic and ecological risks of hatchery production were discussed with respect to the major theoretical and observed effects to wild salmonid populations. Table C-55 provided a cross-reference index that associates the risk issues to the various hatchery practices and management decisions that have the potential to affect those risks. This section provides the analysis approach that is used to assess these risks. Due to the diversity of hatchery operations, this discussion is organized into seven categories that encompass functional requirements. Following each hatchery operations category is a table that ranks the risk of various hatchery practices. The evaluation will focus on the process of implementing the most effective management approach for achieving recovery of listed fish species.

C.1.10.5.1 Sources of Broodstock

The source(s) of broodstock for the Russian River should be guided, in part, by the following considerations:

- Can salmonids captured within the Russian River and tributaries be expected to provide the genetic and life-history diversity necessary to successfully repopulate the Russian River and eventually provide for self-sustaining natural populations?

- Can restoration efforts be aided by importation of steelhead from nearby basins, or is the scale of local adaptation smaller (e.g., between spawning aggregates within a basin)?

- Do alternate broodstock sources inhabit watersheds with selective regimes similar to the Russian River?

An isolated harvest program would derive all broodstock from the supply of adult salmonids returning to the hatchery. For supplementation and integrated harvest programs, the annual source of broodstock would come from the wild population, wherever possible. The selection of a broodstock source for a supplementation or integrated harvest program ultimately will be dictated by availability. Within the constraints of availability, the following priorities are recommended:

1. Naturally-spawned broodstock collected in the most unbiased manner possible from the local target population(s), provided that collection of broodstock does not endanger the population.

2. Naturally-spawned adults from the nearest watershed, provided that collection of broodstock does not endanger the population. If several such sources are available, managers may wish to choose the location(s) that have a high probability of maintaining transfers, and that most closely match the environmental characteristics of the Russian River and tributaries. Further, when possible, managers may wish to consider using cryopreserved milt from local sources, if and when available, to fertilize the eggs of transferred females.

3. Hatchery-reared adults collected in the most unbiased manner possible from the local population.

4. Hatchery-reared adults from the nearest watershed, provided that broodstock collection is not unduly prohibitive for the donor hatchery program. If several such sources are available, managers may wish to choose the location(s) that have a high probability of maintaining transfers, and whose natural habitat most closely matches the environmental characteristics of the Russian River and tributaries. Further, when possible, managers may wish to consider using cryopreserved milt from local sources, if and when available, to fertilize the eggs of transferred females.

5. Naturally-spawned broodstock collected from within the same Evolutionarily Significant Unit (ESU), following the criteria described in priority two, above.

6. Hatchery-reared adults collected from within the same ESU, following the criteria described in criteria three, above.

7. Naturally-spawned broodstock or juveniles collected from a different ESU, following the criteria described in priority two, above.

8. Hatchery-reared adults or juveniles collected from a different ESU, following the criteria described in criteria three, above.

In general, the list of priorities is ordered from the least-to-most risky, and highest-to-lowest probability of success. This determination is based on the fact that the scale, magnitude, and biological significance of local adaptation are not fully understood. It follows that adults derived from the target population(s) would be the most ideal candidates for supplementation or integrated harvest programs, since these individuals may exhibit phenotypes that have been influenced by the natural selection regime of the local environment (i.e., locally adapted). Therefore, it is expected that the probability of short-term supplementation or integrated harvest success may be lower if adults are transferred from other watersheds, and the degree to which success may be hindered could be proportional to the distance of the transfer (Reisenbichler 1988). However, if the local population(s) is severely depressed, it is possible that the genetic and life-history variation present in the stock may be insufficient for adaptation to current and changing conditions within the Russian River watershed (Newman and Pilson 1997). For example, in small populations subject to high rates of random mortality, genetic drift may exert a stronger influence than natural selection (Adkison 1995). In such cases, it is possible that the potential benefits of using the local population as a source (e.g., potential local adaptation) of adults may be offset by low overall genetic variation, and that a transfer of exogenous genetic variation may provide a broader genetic background upon which natural selection can act (see Lewontin and Birch 1966), although this is not always the case (Leberg 1993).

The potential to use an existing hatchery stock as a donor further complicates the list of broodstock priorities. While the use of an existing hatchery stock has been at least partially successful in some cases (Phillips et al. 2000), this strategy should be approached cautiously (except for the isolated harvest alternative). The history of stock transfers and the management of the donor hatchery program should be reviewed in detail to determine if adults exhibit the ability to reproduce and function in the natural environment. For example, several studies have demonstrated that hatchery-reared fish may exhibit decreased survival and productivity relative to natural-origin fish under natural conditions (e.g., Fleming and Gross 1993), although research has also demonstrated that this is not always the case (Rhodes and Quinn 1999). Therefore, the decision to use a hatchery as a source of adults or juveniles versus naturally-spawned adults or juveniles from a more distant location should be carefully considered.

The source of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanism of outbreeding depression. Depending on specific circumstances, the source of broodstock also has potential to contribute to loss of within-population or between-population diversity, inbreeding depression, or straying of the hatchery-reared component. However, by utilizing local stocks as the source of broodstock, the source of genetic material in the first-generation hatchery component is presumably identical to that of the wild population.

In cases where the abundance of local stocks are insufficient to meet the broodstock demand, then the priorities noted at the beginning of this section can provide the basis for selecting alternative sources while minimizing risk to the wild population. Table C-56 organizes the recommended priorities for broodstock source into five categories and provides each category with a score of relative risk level. Since the local stock is the recommended source of broodstock for both supplementation and integrated harvest production alternatives, there is no difference in risk level between these alternatives and the no production alternative. However, until such time that there are adequate numbers of wild salmonids to assure that broodstock harvest would not affect the target stock, it is recommended that a mix of hatchery-reared and naturally spawning broodstock be utilized to satisfy the minimum broodstock goals.

Table C-56 Source of Broodstock Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	Local broodstock source (target stock), collected in the most unbiased manner possible.
4	Naturally-spawned broodstock source from the nearest watershed; or a combination of naturally-spawned and hatchery-reared broodstock from the local source.
3	Hatchery-reared broodstock source from the local or nearest watershed; or naturally-spawned broodstock source from within the same ESU.
2	Hatchery-reared broodstock source from within the same ESU; or naturally-spawned broodstock source from a different ESU.
1	Hatchery-reared broodstock source from a different ESU.

C.1.10.5.2 Numbers of Broodstock

Escapement Goals Based on Genetic Criteria

Escapement and broodstock goals are based on probabilities associated with maintaining genetic variation and limiting demographic risks, both to the hatchery-reared and naturally-spawned components of the Russian River population(s). Except for an isolated harvest alternative, the escapement and broodstock goals are formulated to provide for "genetic and life-history redundancy;" that is, in the event that a brood year is lost either in the hatchery as a result of catastrophic failure, or in the stream as a result of a random environmental event, the surviving component should maintain sufficient genetic and life-history variation to maintain the stock. To reasonably ensure this redundancy requires that the hatchery and naturally spawning population components are representative of one another both genetically and in life-history characteristics, and that both components are maintained at a large size, which may be unrealistic in the short-term for a listed species. In addition, it is implicitly assumed that hatchery practices will not grossly alter life-history characteristics. This assumption may or may not hold true as discussed elsewhere in this document.

Within the body of peer-reviewed conservation literature there exists a wide range of population sizes deemed acceptable for the maintenance of genetic and life-history diversity. These estimates range from as low as 500 adults per generation (or approximately 167 adults per year in the case of coho salmon, Soulé 1980) to as high as 1,000 spawning adults per year (Rieman and Allendorf 2001) for naturally spawning populations. With regards to hatchery programs, as few as 200 adults can provide the basis for a reasonably healthy broodstock (Allendorf and Ryman 1987).

Most estimates of minimum viable population size are based on maintenance of genetic variation. Although the maintenance of genetic variation is certainly not the only consideration for conservation programs, it is widely accepted that the maintenance of genetic variation is critical for maintaining fitness and the ability to respond to a changing environment. It is also widely accepted that the maintenance of genetic variation is linked to population size (Frankham 1995a, 1995b), although this relationship is sometimes obscure (Kelly 2001).

To formulate escapement goals for Russian River steelhead and coho salmon, an estimate was made of the number of adults per year required to maintain a 95 percent probability that alleles occurring at a frequency of 1 percent or greater would be retained for three generations (15 years) for steelhead, five generations (15 years) for coho salmon, and three generations (15 years) for Chinook salmon within both the hatchery and natural components of the Russian River watershed. This rate of retention is supported as a reasonable goal for conservation programs (Allendorf and Ryman 1987, Kapuscinski 1991). A period of 15 years was selected to allow the completion of the habitat restoration activities that will likely be required to improve sustainability of naturally spawning Russian River salmonids. Rates of allele retention are based on the following binomial equation:

$$P_R = 1-(1-p)^{2(\text{generation length})(Nb)}$$

Where:

P_R = probability of maintaining a rare allele

p = frequency of the rare allele

N_b = yearly effective population size

Over a period of several generations the probability is described as:

$$P_{RC} = P_R^G$$

Where:

P_{RC} = cumulative probability of maintaining a rare allele

G = number of generations

To utilize these equations, an estimate of the ratio of effective number of breeders (N_b) to the census population size N in a given year is required. Estimates of both of these parameters were not available specifically for Russian River salmonids, so estimates from the literature were employed. Within the literature, effective population size (N_e) to census population size (N) ratios averaged 0.10 across taxa (Frankham 1995b), and varied from 0.04 to 0.83 among salmonids (Simon et al. 1986, Bartley et al. 1992). Average effective population sizes for salmonids are reported to be 0.2 (Allendorf et al. 1997), 0.3 (McElhany et al. 2000), or 0.33 (Hedrick and Hedgecock 1994). In the following sections, estimates are provided of the population size necessary to maintain a 95 percent probability of retaining alleles at a frequency of 1 percent or greater, over a period of one to five generations, assuming a range of N_e/N ratios. To provide a conservative estimate, final escapement goals are based on an N_e/N ratio of 0.2. Finally, to provide estimates of yearly broodstock and escapement needs, N_e/N ratios were transformed to N_b/N ratios by dividing N_e by the mean generation length of steelhead (5 years), and coho salmon and Chinook salmon (3 years) following Waples (1990).

It should be noted that several simplifying assumptions are necessary to utilize this methodology. Obviously, it must be assumed that the range of effective population size ratios is appropriate for Russian River salmonids. Second, the precision of allele retention estimates spanning more than one generation is greatly effected by the stability of allele frequencies. If allele frequencies fluctuate substantially between generations, the precision of allele frequency estimates will be low. Nonetheless, these methods will likely provide a reasonable estimate for managers until such time as Russian River-specific data are available. Third, strictly speaking, these estimates are applicable primarily to neutral genetic variation; however, additive genetic variation for quantitative traits might be expected to follow a similar pattern, since it is linked to heterozygosity, and is expected to decline proportionally (Falconer and Mackay 1996). Fourth, this method assumes that all individuals in a population are equally likely to be sampled. In practice, this assumption may not hold true, particularly if there is a high risk that a few families will be over-represented by inherent biases in sampling protocols and/or difficulties associated with randomly sampling small, geographically dispersed populations.

Finally, these estimates should be regarded as minimum escapement estimates. In particular, escapement goals based on genetic criteria may be far too small to provide an ample buffer against random environmental stochasticity experienced by naturally spawning fish.

Instream and Hatchery Broodstock Escapement Goals

As mentioned previously, escapement goals are formulated to provide genetic redundancy. To achieve this goal, instream spawning and hatchery broodstock goals are formulated to provide a 95 percent probability of retaining alleles occurring at a frequency of 1 percent or greater within each component of the Russian River population for a period of three steelhead generations (15 years), five coho salmon generations (15 years), and five Chinook salmon generations (15 years). Such a strategy assures (probabilistically) that genetic variation will be maintained even if one of the two population components suffers complete reproductive failure. Assuming an N_b/N ratio of 0.2, approximately 200 adult steelhead spawners (Table C-57), approximately 400 adult coho salmon spawners (Table C-59), and approximately 230 adult Chinook salmon spawners (Table C-60) are required in each environment to meet this goal. Tables C-58, C-60 and C-62 list the number of adult steelhead, coho salmon, and Chinook salmon spawners, respectively, necessary to maintain genetic variation assuming various N_b/N ratios. If coho salmon juveniles are collected to form a captive brood, juvenile collections would have to be substantially larger to provide 420 adults for broodstock. Assuming a 40 percent fry to adult survival rate[2] in captivity (Arkush et al. 1997), approximately 588 fry would be required to achieve the adult spawning goal within the hatchery.

[2] Juvenile collection thus far has focused on more advanced life-history stages. Fry survival estimates were used to provide a conservative estimate.

Table C-57 Number of Steelhead Adults Required for Broodstock to Maintain a 95 Percent Probability of Maintaining Alleles at a Frequency of 1 Percent or Greater for 15 Years (3 Steelhead Generations) (Assuming an N_b/N Ratio of 0.2)

Broodstock Size	Nb	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
50	10	0.63	0.40	0.25	0.16	0.10
100	20	0.87	0.75	0.65	0.56	0.49
150	30	0.95	0.90	0.86	0.82	0.78
200	40	0.98	0.96	0.95	0.93	0.91
250	50	0.99	0.99	0.98	0.97	0.97
300	60	1.00	1.00	0.99	0.99	0.99
350	70	1.00	1.00	1.00	1.00	1.00
400	80	1.00	1.00	1.00	1.00	1.00
450	90	1.00	1.00	1.00	1.00	1.00

Table C-58 Estimated Rates of Allele Retention (at a Frequency of 1 Percent or Greater) for Broodstocks of 100, 200, and 400 Steelhead Adults (Assuming a Range of N_b/N Ratios)

Broodstock of 100 Adults						
Nb/N	Nb	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
0.1	10	0.634	0.402	0.255	0.162	0.102
0.2	20	0.866	0.750	0.650	0.562	0.487
0.3	30	0.951	0.904	0.860	0.818	0.778
0.4	40	0.982	0.964	0.947	0.930	0.913
0.5	50	0.993	0.987	0.980	0.974	0.968
0.6	60	0.998	0.995	0.993	0.990	0.988
0.7	70	0.999	0.998	0.997	0.996	0.996
Broodstock of 200 Adults						
0.1	20	0.866	0.750	0.650	0.562	0.487
0.2	40	0.982	0.964	0.947	0.930	0.913
0.3	60	0.998	0.995	0.993	0.990	0.988
0.4	80	1.000	0.999	0.999	0.999	0.998
0.5	100	1.000	1.000	1.000	1.000	1.000
0.6	120	1.000	1.000	1.000	1.000	1.000
0.7	140	1.000	1.000	1.000	1.000	1.000

Table C-58 Estimated Rates of Allele Retention (at a Frequency of 1 Percent or Greater) for Broodstocks of 100, 200, and 400 Steelhead Adults (Assuming a Range of N_b/N Ratios) (Continued)

Broodstock of 400 Adults						
0.1	40	0.982	0.964	0.947	0.930	0.913
0.2	80	1.000	0.999	0.999	0.999	0.998
0.3	120	1.000	1.000	1.000	1.000	1.000
0.4	160	1.000	1.000	1.000	1.000	1.000
0.5	200	1.000	1.000	1.000	1.000	1.000
0.6	240	1.000	1.000	1.000	1.000	1.000
0.7	280	1.000	1.000	1.000	1.000	1.000

Table C-59 Number of Coho Salmon Adults Required for Broodstock to Maintain a 95 Percent Probability of Maintaining Alleles at a Frequency of 1 Percent or Greater for 15 Years (Five Coho Salmon Generations) (Assuming an N_b/N Ratio of 0.2)

Broodstock Size	N_b	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
50	10	0.45	0.21	0.09	0.04	0.02
100	20	0.70	0.49	0.34	0.24	0.17
150	30	0.84	0.70	0.58	0.49	0.41
200	40	0.91	0.83	0.75	0.69	0.63
250	50	0.95	0.90	0.86	0.82	0.78
300	60	0.97	0.95	0.92	0.90	0.87
340	68	0.98	0.97	0.95	0.94	0.92
350	70	0.99	0.97	0.96	0.94	0.93
400	80	0.99	0.98	0.98	0.97	0.96
450	90	1.00	0.99	0.99	0.98	0.98

Table C-60 Estimated Rates of Rare Allele Retention (Occurring at a Frequency of 1 Percent or Greater) for Broodstocks of 100, 200, and 400 Coho Salmon Adults (Assuming a Range of N_b/N Ratios)

Broodstock of 100 Adults						
N_b/N	**N_b**	**One**	**Two**	**Three**	**Four**	**Five**
0.1	10	0.453	0.205	0.093	0.042	0.019
0.2	20	0.701	0.491	0.344	0.241	0.169
0.3	30	0.836	0.699	0.585	0.489	0.409
0.4	40	0.910	0.829	0.754	0.687	0.625
0.5	50	0.951	0.904	0.860	0.818	0.778
0.6	60	0.973	0.947	0.922	0.897	0.873
0.7	70	0.985	0.971	0.957	0.943	0.929
Broodstock of 200 Adults						
Nb/N	**Nb**	**One**	**Two**	**Three**	**Four**	**Five**
0.1	20	0.701	0.491	0.344	0.241	0.169
0.2	40	0.910	0.829	0.754	0.687	0.625
0.3	60	0.973	0.947	0.922	0.897	0.873
0.4	80	0.992	0.984	0.976	0.968	0.960
0.5	100	0.998	0.995	0.993	0.990	0.988
0.6	120	0.999	0.999	0.998	0.997	0.996
0.7	140	1.000	1.000	0.999	0.999	0.999
Broodstock of 400 Adults						
Nb/N	**Nb**	**One**	**Two**	**Three**	**Four**	**Five**
0.1	40	0.910	0.829	0.754	0.687	0.625
0.2	80	0.992	0.984	0.976	0.968	0.960
0.3	120	0.999	0.999	0.998	0.997	0.996
0.4	160	1.000	1.000	1.000	1.000	1.000
0.5	200	1.000	1.000	1.000	1.000	1.000
0.6	240	1.000	1.000	1.000	1.000	1.000
0.7	280	1.000	1.000	1.000	1.000	1.000

Table C-61 Number of Chinook Salmon Adults Required for Broodstock to Maintain a 95 Percent Probability of Maintaining Alleles at a Frequency of 1 Percent or Greater for 15 Years (5 Generations) (Assuming an N_b/N Ratio of 0.2)

Broodstock Size	Nb	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
50	10	0.63	0.40	0.25	0.16	0.10
100	20	0.87	0.75	0.65	0.56	0.49
150	30	0.95	0.90	0.86	0.82	0.78
200	40	0.98	0.96	0.95	0.93	0.91
230	46	0.99	0.98	0.97	0.96	0.95
250	50	0.99	0.99	0.98	0.97	0.97
300	60	1.00	1.00	0.99	0.99	0.99
350	70	1.00	1.00	1.00	1.00	1.00
400	80	1.00	1.00	1.00	1.00	1.00
450	90	1.00	1.00	1.00	1.00	1.00

Table C-62 Estimated Rates of Allele Retention (at a Frequency of 1 Percent or Greater) for Broodstocks of 100, 200, and 400 Chinook Salmon Adults (Assuming a Range of N_b/N Ratios)

Nb/N	Nb	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
Broodstock of 100 Adults						
0.1	10	0.634	0.402	0.255	0.162	0.102
0.2	20	0.866	0.750	0.650	0.562	0.487
0.3	30	0.951	0.904	0.860	0.818	0.778
0.4	40	0.982	0.964	0.947	0.930	0.913
0.5	50	0.993	0.987	0.980	0.974	0.968
0.6	60	0.998	0.995	0.993	0.990	0.988
0.7	70	0.999	0.998	0.997	0.996	0.996
Broodstock of 200 Adults						
0.1	20	0.866	0.750	0.650	0.562	0.487
0.2	40	0.982	0.964	0.947	0.930	0.913
0.3	60	0.998	0.995	0.993	0.990	0.988
0.4	80	1.000	0.999	0.999	0.999	0.998
0.5	100	1.000	1.000	1.000	1.000	1.000
0.6	120	1.000	1.000	1.000	1.000	1.000
0.7	140	1.000	1.000	1.000	1.000	1.000

Table C-62 Estimated Rates of Allele Retention (at a Frequency of 1 Percent or Greater) for Broodstocks of 100, 200, and 400 Chinook Salmon Adults (Assuming a Range of N_b/N Ratios) (Continued)

Nb/N	Nb	Generation One	Generation Two	Generation Three	Generation Four	Generation Five
Broodstock of 400 Adults						
0.1	40	0.982	0.964	0.947	0.930	0.913
0.2	80	1.000	0.999	0.999	0.999	0.998
0.3	120	1.000	1.000	1.000	1.000	1.000
0.4	160	1.000	1.000	1.000	1.000	1.000
0.5	200	1.000	1.000	1.000	1.000	1.000
0.6	240	1.000	1.000	1.000	1.000	1.000
0.7	280	1.000	1.000	1.000	1.000	1.000

Minimum Escapement Goal

Calculating a minimum escapement estimate is not as straightforward as adding escapement goals for each population component. In a sense, escapement of 420 steelhead adults (210 for natural spawning and 210 for broodstock) or 840 coho salmon adults (420 for natural spawning or 420 for broodstock) would be sufficient to meet instream spawning and broodstock needs for a given year. However, the number of adults contributing to the next generation is expected to be higher for adults spawned in the hatchery than adults spawning in the natural environment. Therefore, given that natural production is likely below replacement for naturally spawning salmonids in the Russian River, substantially more adults will be required for natural spawning to ensure that escapement is sufficient in the next generation.

Further, it is assumed that hatchery rearing will provide a substantial survival benefit relative to natural spawning. As a result, escapement in the next generation is expected to be much higher for hatchery-reared adults relative to naturally-spawned adults if the population components are of roughly equivalent size in the present generation. Therefore, escapement for natural spawning may have to be much higher than the minimum estimates derived above, to provide for the infusion of naturally-spawned broodstock into the hatchery program. In addition, far more hatchery-reared adults will be available for natural spawning and hatchery rearing.

Ryman et al. (1994) provide a simple equation to account for differential reproductive success experienced by adults in the hatchery versus natural environment. The variance-effective population size (N_e)[1] of the combined population (including adults of hatchery

[1]Variance-effective population size is one component of total effective population size N_e. Strictly speaking, all estimates of N_e discussed in this plan refer to variance-effective population size.

and natural origin) expected to return in the next generation, can be estimated by the following equation:

$$N_b=(1-1/2N)/(1/N'^2(N'+(N'_c(N'_c-0.5)/N_c)+(N'_w(N'_w-0.5)/N_w))-1/N)$$

Where:

N_b = total yearly effective population size at time t+1

N_c = N_b of the broodstock for the hatchery-reared component

N'_c = N_b returning in the next generation as a result of hatchery rearing

N_w = N_b of the naturally spawning population component

N'_w = N_b returning in the next generation as a result of natural spawning

N = total population size at time t

N' = total population size in the next generation (t+1)

For example, using the escapements formulated previously for steelhead, (210 spawners in each environment), and assuming an adult return rate of 0.5 and 4, respectively, for instream and hatchery spawners, contribution to the next generation would be 105 and 840 adults of natural and hatchery origin, respectively. Ultimately, for reasons relating to artificial selection, it would be appropriate to maintain a minimum escapement goal that would allow for collection of broodstock solely from naturally-spawned adults. With a natural return rate of 0.5, this would require instream spawning by a minimum of 420 adults to return 210 adults to the next generation (which could be a combination of natural and hatchery origin individuals). Therefore, assuming 5 percent prespawn mortality in each environment, a minimum escapement of 630 adults per year would be required for a steelhead supplementation or integrated harvest program.

Using the escapements formulated previously for coho salmon (420 spawners in each environment), and assuming an adult return rate of 0.5 and 4, respectively, for instream and hatchery spawners, contribution to the next generation would be 210 and 1,680 adults of natural and hatchery origin, respectively, with a combined N_b of 168 as determined by the equation above. Ultimately, for reasons relating to artificial selection, it would be appropriate to maintain a minimum escapement goal that would allow for collection of broodstock solely from naturally-spawned adults. With a natural return rate of 0.5, this would require instream spawning by a minimum of 840 adults (which could be a combination of natural and hatchery origin individuals). Therefore, assuming 5 percent prespawn mortality in each environment, a minimum escapement of 1,322 adults per year is required.

Using the escapements formulated previously for Chinook salmon (242 spawners in each environment), and assuming an adult return rate of 0.5 and 4, respectively, for instream and hatchery spawners, contribution to the next generation would be 121 and 968 adults of natural and hatchery origin, respectively. Ultimately, for reasons relating to artificial selection, it would be appropriate to maintain a minimum escapement goal that would allow for collection of broodstock solely from naturally-spawned adults. With a natural return rate of 0.5, this would require instream spawning by a minimum of 484 adults to return 242 adults to the next generation (which could be a combination of natural and hatchery origin individuals). Therefore, assuming 5 percent prespawn mortality in each environment, a minimum escapement of 726 adults per year would be required for a Chinook salmon supplementation or integrated harvest program.

The numbers of broodstock used in hatchery operations has the potential to affect the wild population primarily through the mechanisms of inbreeding depression and loss of within-population diversity. However, by determining and using the minimum number of broodstock necessary to maintain the genetic variability of the population, the risk of genetic effect is minimized. Table C-63 organizes the potential range broodstock availability into five categories with a score of relative risk level.

Table C-63 Numbers of Broodstock Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	Maintenance of N_b necessary to maintain genetic variation with a 95% probability, in both instream and hatchery components.
4	Instream escapement > 50% N_b and hatchery broodstock > 75% N_b.
3	Instream escapement < 50% N_b and hatchery broodstock > 50% N_b.
2	Instream escapement < 50% N_b and hatchery broodstock < 50% N_b.
1	Instream escapement < 50% N_b.

N_b is the effective number of breeders.

C.1.10.5.3 Broodstock Sampling and Mating Protocols

To minimize the genetic and life-history differentiation between hatchery and wild fish, the theoretical ideal for broodstock collection would be to sample the entire breeding population. However, as this is not a practical approach to preserving the wild population, it is generally required that a systematic subsampling scheme be developed that minimizes risk to the wild population. The following broodstock sampling and mating protocols are recommended by NOAA Fisheries (Hard et al. 1992):

- A primary goal of the sampling program should be to obtain a representative sample for use as broodstock while allowing a representative sample to remain in the wild.
- Sampled adults should represent the entire run with regard to size, age, and other measurable phenotypic characters that may have adaptive value.
- If the number of available natural spawners is large enough to permit a large sample to be taken, random sampling (sampling without regard to measurable characters) is likely to ensure that the natural population is represented adequately in the broodstock. If the number of natural spawners is too small to permit a large sample, however, systematic sampling on the basis of measurable characters

(particularly run-timing and size and age at maturity) may be required to achieve adequate representation.

Maintaining genetic characteristics of a population during artificial propagation may also be affected by the manner in which the broodstock are mated. In theory, there would appear to be an advantage to mimic mating strategies that occur in the wild. However, the understanding of patterns of reproductive success in natural populations is incomplete, particularly with respect to males, and NOAA Fisheries consequently discourages attempts to mimic natural spawning behavior in the hatchery (Hard et al. 1992).
The mating protocols recommended by NOAA Fisheries consist of the following (Hard et al. 1992):

- The mating design should be chosen to equalize as much as possible the contributions of parents to the next breeding generation. This procedure will maximize N_e for a given number of breeders and minimize the effects of selection.

- If possible, parents should be mated at random with regard to phenotypic characters that may have adaptive value (e.g., age and size at maturity).

- Mating design may include matings of single pairs, matings of single females to overlapping pairs of males, or factorial designs involving crosses between all possible parents. A modified single-pair design is generally preferable to simple matings of single pairs because it reduces risk of loss due to infertile males. A factorial design, assuming that the realized variance in progeny number is small, increases the probability of unique genetic combinations in the progeny. However, a complete factorial design will generally be feasible only with very small populations, since the benefits rapidly decrease (and the logistical difficulties rapidly increase) with increasing numbers of adults.

- Gametes from different individuals should not be mixed prior to fertilization, since mixing would affect the contribution of some individuals if there is variability in the potency of milt.

- In very small populations, a fraction of the milt from each male should be cryopreserved to maintain a "sire bank." These gametes can provide additional male “breeders” in years when the number of available males is low. Moreover, such crosses between brood years can help to preserve long-term genetic variability if severe population bottlenecks have been frequent or persistent.

In summary, broodstock sampling and mating protocols have the potential to affect the wild population primarily through the mechanisms of loss of within-population diversity and outbreeding depression. Table C-64 organizes the potential range of sampling and mating procedures into five categories and provides a score of relative risk level.

Table C-64 Broodstock Sampling and Mating Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	Large, naturally spawning component allowing random mating.
4	Large broodstock with pedigree mating.
3	Large broodstock with random mating; or medium broodstock with pedigree mating.
2	Medium broodstock with random mating; or small broodstock with pedigree mating.
1	Random mating precluded in naturally spawning component (due to small population size and/or isolation).

C.1.10.5.4 Rearing Techniques

Naturalized Rearing Environments

The degree to which artificial selection might be expected to result in the divergence of phenotypes among hatchery-reared adults and or juveniles is related in large part to the difference in selective regimes between the hatchery and natural environment. One obvious method to decrease the potentially deleterious effects of artificial selection is to minimize selective differences between the two environments. One approach for doing so is implementation of the Natural Rearing Enhancement System (NATURES) described by Maynard et al. (1996). The NATURES approach uses naturally colored raceways and rearing ponds, natural substrates, instream cover, subsurface feeding, and lower rearing densities (among other factors) in an effort to mimic natural conditions in the hatchery. Although implementation of these methods may not increase survival *per se*, implementation of NATURES methods might be useful as a means to avoid cryptic side effects of artificial selection. For example, it has been postulated that rearing in environments that have homogeneous flows (e.g., raceways) may result in hatchery-reared progeny that are unable to identify and utilize less energetic low-flow areas in natural streams (Olla et al. 1998). By introducing hatchery-reared progeny to varied currents within a raceway, either by introduction of cover or S-shaped raceways, the NATURES program may increase the ability of hatchery-reared progeny to function effectively under natural conditions.

Environmental conditions in the hatchery that attempt to simulate natural conditions are likely to reduce typical differences between hatchery and natural fish. Examples of naturalized rearing conditions that are being investigated through the NATURES research program include substrate coloration and composition and in-water structures to provide variable water flow conditions. Low rearing density indices (between 0.30 and 0.40 pounds of fish per cubic foot of water per inch of fish length) are recommended by NOAA Fisheries as a means to maximize adult return (Flagg et al. 2000). At a minimum, it is expected that any supplementation or captive brood program would operate under low-density conditions, and that NATURES features would be added as data become more conclusive regarding their benefit to minimizing artificial selection and increasing adult return.

Given that differences in selective regimes experienced by hatchery-reared versus naturally-spawned individuals can contribute to artificial selection, it follows that decreasing the selective gradient between the hatchery and instream environment can minimize the risk of artificial selection. Therefore, it is proposed that one criterion by which the risk of artificial selection can be assessed is the degree to which managers can minimize differences in selective pressures between the instream and hatchery environments. To do so, it is recommended that elements of the NATURES rearing program be implemented, and that the number of NATURES techniques employed be used as the ranking criterion for rearing techniques.

Rearing techniques have potential to affect the wild population primarily through the mechanism of artificial selection. Table C-65 organizes the potential range of rearing techniques into five categories and provides a score of relative risk level.

Table C-65 Rearing Techniques Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	No hatchery captivity.
4	Low-density rearing with multiple NATURES features.
3	Low-density rearing.
2	High-density rearing with NATURES features.
1	High-density rearing.

Fish Health

To minimize the risk of disease transfer to the wild population, hatchery operations should include adequate safeguards for fish health. NOAA Fisheries recommends the following fish health protocols (Hard et al. 1992):

- Adults contributing gametes should be regularly sampled for pathogens of common salmonid diseases.
- Incubation facilities should be sterilized before gametes are transported to them.
- Gametes brought into the facility should be isolated from all others and the resulting fertilized eggs disinfected. To avoid horizontal disease transfer, progeny should be isolated by full-sib family until cleared though pathological testing and then monitored regularly during culture.
- Infected fish should be isolated and treated. However, it should be recognized that some incipient level of disease is natural and also probably essential for immunological readiness for episodic outbreaks.
- If necessary, the hatchery water supply and effluent should be treated to minimize the transfer of pathogens to and from the natural population.

It is assumed that adherence to NOAA Fisheries-recommended guidelines for fish health management will minimize potential risk of disease transfer from the hatchery to wild populations to an undetectable level.

Release Strategies

Age of Releases

Different lifestages of fish may experience differing levels of resource limitation, depending on the time and duration of resource utilization. There is a benefit to fish production goals that minimize temporal overlap in the hatchery-reared and naturally-spawned components, suggesting a preference for smolt release programs over fingerling production. Hatchery-reared fish released as smolts soon migrate to the ocean, and they consequently exhibit little likelihood of competing for freshwater resources utilized by naturally-spawned fingerling rearing within the system. It is recommended that any mitigation or supplementation production program in the Russian River release smolts.

Release Size

The size of a juvenile fish has been shown to affect its ability to compete, escape predators, and survive the ocean phase of its life-history. Stocking with hatchery-reared juveniles of a similar size to naturally-spawned individuals may decrease the probability of competition or predation, and minimize selection pressures that may accompany a clear difference in size. It is recommended that any production programs in the Russian River release smolts within the observed size range of wild smolts.

Acclimation and Volitional Release

If population sizes are small, managers should seek to avoid erosion of between-population diversity by maintaining the highest possible degree of homing fidelity. Straying can be minimized by rearing and acclimation using water from the stream to which adults are hoped to return (Dittman et al. 1994, 1996). Therefore, mitigation for the loss of between-population diversity could be in the form of acclimation facilities.

Fished reared at conservation hatcheries should be released on their own volition, based on the assumption that fish will not leave the hatchery until the physiological process of smoltification triggers their downstream migratory behavior. The time-frame provided for volitional release should mimic the time and age patterns found in wild populations. Within this framework, fish may leave if they wish or remain behind to fend for themselves and smolt, residualize or perish as natural selection takes its course (Flagg et al. 2000). It is important that no attempt be made to reduce natural variation in size at release (Hard et al. 1992).

It is recommended that conservation hatcheries adopt practices aimed at reducing straying to no more than 5 percent. It has been shown that juvenile fish must experience the odors of their natal system at various physiological states to maximize imprinting opportunity. Conservation hatcheries should consequently rear fish for their entire juvenile freshwater lives in water from the intended return location. When this is not possible, a period of acclimation on intended return water should be conducted (Flagg et al. 2000), preferably for a minimum of four weeks.

Release Locations

Releases of fish for supplementation purposes should occur only in locations where the habitat capacity exceeds the requirements of the local naturally spawning population. This indicates the importance for resource managers to identify the area of habitat utilization for various lifestages. Ideally, this information should be used to establish production goals for hatchery operations, specifying production numbers for specific sizes (i.e., lifestages) and release locations. Further, for supplementation-type programs, there is a strong benefit of providing frequent updates to population surveys of both hatchery-reared and naturally-spawned fish. Adaptive management can then be used to evaluate and implement changes in program goals and/or techniques for artificial propagation. For example, the limiting factor in the mainstem Russian River is generally thought to be rearing habitat, particularly for larger juveniles, due to high summer water temperatures (below Cloverdale). Release of steelhead into restored rearing habitat where steelhead have been extirpated or abundance is low, would minimize negative competitive interactions. Monitoring and evaluation over time can provide data to guide future release strategies as steelhead abundance changes.

For the isolated harvest production alternative, managers can consider releasing fish to increase the spatial and temporal separation between hatchery and wild fish. Approaches might include releasing steelhead smolts after wild salmonids have moved out of estuarine habitats, and releasing smolts downstream of habitat used by wild salmonids. Another alternative might consider intentional development of hatchery strains with different migrational timing than other wild salmonids in the basin. However, the potential benefits of this ecological isolation would have to be carefully weighed against the potential risk of developing genetically divergent stocks.

Release strategies have the potential to affect the wild population through several ecological interactions, as outlined previously. Table C-66 organizes the potential range of release strategies into five categories and provides a score of relative risk level. It is assumed that habitat conditions will be surveyed for multiple years prior to juvenile releases to determine appropriate release locations and densities. Although there would be a preference to develop acclimation facilities to allow volitional release in these locations, it is recognized that the large extent of private land ownership in the Russian River watershed is a factor that may affect the opportunity for such facilities.

Table C-66 Release Strategies Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	No hatchery releases.
4	Volitional smolt releases into areas with known habitat carrying capacity.
3	Direct smolt releases into areas with known habitat carrying capacity.
2	Volitional smolt releases into areas with unknown habitat carrying capacity.
1	Direct smolt releases into areas with unknown habitat carrying capacity.

C.1.10.5.5 Duration in Hatchery Captivity

The duration of hatchery captivity has potential to affect the wild population primarily through the mechanism of artificial selection. The rate and extent to which phenotypic, genetic, and behavioral divergence may occur within the hatchery environment is largely dependent on selective pressure within the hatchery, and the number of generations the hatchery-reared stock has been isolated from the donor stock. Typically, divergence requires many generations. However, under intentional selection, there can be evidence of divergence after only two generations (Beasley et al. 1999).

Many sources of artificial selection that could occur in a hatchery can be avoided, such as assuring there is representative sampling of all available broodstock. However, it is not possible to avoid all sources of artificial selection. For example, culling eggs or juveniles exhibiting a high titer for bacterial kidney disease may result in inadvertent selection against those individuals possessing a natural resistance to the disease. All things being equal, one would expect the number of diverged traits and the magnitude of divergence to increase with the duration of captivity. Simply stated, with a longer period of duration, more life-history stages may be subjected to artificial selection, and more traits may become susceptible to the effects of artificial selection. Table C-67 organizes the anticipated range of hatchery captivity into five categories and provides each program alternative with a score of relative risk level.

Table C-67 Duration in Hatchery Captivity Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	No hatchery captivity.
4	Hatchery captivity through fry lifestage.
3	Hatchery captivity through smolt lifestage.
2	Hatchery captivity through adult lifestage.
1	Hatchery captivity for repeated generations.

C.1.10.5.6 Harvest Management

Harvest management has potential to affect the wild population primarily through the mechanism of unintended harvest bycatch of the non-target population. To reduce the potential for deleterious effects, it is essential to monitor the effects of harvest on listed populations. Budget limitations have precluded the ability of CDFG to conduct harvest surveys in recent years, but there is indication that funding may be available soon for such activities (Royce Gunter, CDFG, pers. comm. 2002). Table C-68 organizes the potential range of harvest management decisions into five categories and provides each program alternative with a score of relative risk level.

Table C-68 Harvest Management Evaluation Criteria

Category Score	Evaluation Criteria Categories
5	No harvest allowed within basin.
4	Harvest allowed on one or more non-listed, distinguishable/marked population, with comprehensive surveys to assess harvest, angler effort, and bycatch effects to wild population.
3	Harvest allowed on one or more non-listed, distinguishable/marked population, with moderate survey activity.
2	Harvest allowed on one or more non-listed, distinguishable/marked population, with minimal survey activity.
1	No limits on harvest.

C.1.11 ESTUARY MANAGEMENT

The primary action in the management of the Russian River Estuary (Estuary) is artificial breaching of a sandbar that forms naturally across the mouth of the river. The Estuary goes through a natural cycle of sandbar formation and breaching. When the sandbar closes, it forms a lagoon. When it is open, the Estuary is open to tidal mixing. A sandbar generally forms during the summer and lasts through early fall, and artificial breaching activities would occur during this time. Sandbar formation is primarily influenced by offshore conditions, coastal sand dynamics, and by river flow.

Information on the historical conditions in the Estuary is scarce prior to the construction of Warm Springs Dam and Coyote Valley Dam, the Potter Valley Project, and water management policies under D1610. Before current policies, it is likely sandbar formation occurred much earlier in the year, lasted until ocean conditions or fall rains breached the sandbar naturally, and the Estuary existed as a closed lagoon during the summer (R. Coey, CDFG, pers. comm. 2000). Salmonid migration patterns were likely well-adapted to the natural opening and closing cycles of the Estuary. Formation of the lagoon was also likely to provide excellent rearing habitat for juveniles.

Under D1610, the amount of water that flows to the Estuary during the dry season has resulted in concerns about local flooding and has forced management to breach the sandbar. Therefore the estuarine system no longer supports a lagoon phase.

For baseline flow conditions under D1610, evaluation criteria for water quality were developed assuming an open estuarine system. Under the proposed project, flow to the Estuary would be reduced and eliminating summer breaching of the sandbar is a viable management option.

C.1.11.1 Issues of Concern

Artificial breaching affects water quality in the Estuary, including salinity, temperature, DO, instream cover, and flow rates. Artificial breaching affects salmonid rearing habitat during the summer and fall. Breaching can alter migration patterns in salmonids and potentially flush juveniles out of the lower Estuary before they are ready to go. It may also increase the risk of predation on listed fish species.

The issues related to artificial breaching are summarized as follows:

- Water quality
- Juvenile rearing
- Adult upstream migration
- Juvenile outmigration
- Flushing juveniles out of the Estuary prematurely
- Predation on salmonids

The effects of artificial breaching on salmonid migration and rearing are characterized using the evaluation criteria for water quality. The risk of predation due to breaching is characterized using the evaluation criteria for predation.

C.1.11.2 Water Quality

When the sandbar closes across the river's mouth, it traps salt water in a lagoon. The denser salt water forms a saltwater lens under the fresh river water (stratification) that traps heat. Through natural processes, DO becomes depleted in the saltwater lens and anoxic conditions can form.

In his studies of central California coast lagoons, Smith (1990) found that the saltwater lens eventually seeps out through the sandbar if it remains closed, and the resulting freshwater conditions provide excellent rearing habitat for steelhead. The rate of conversion to a freshwater system depends on the amount of salt water impounded when the sandbar forms and the amount of river inflow to the system. A sufficient amount of freshwater inflow "freshens" the lagoon and helps to increase the rate of seepage of salt water through the sandbar.

When the sandbar is breached, salt water flows back into the Estuary. Reformation of the sandbar causes salinity stratification to occur and the cycle of freshening starts again. If the sandbar is breached during low-flow periods in the summer, the rate of conversion to a freshwater system can be very slow, and may not occur again that season. This condition results in a return to poor water quality.

If estuaries are managed as open systems, good water quality can be maintained through tidal mixing and/or high river flows (Smith 1990). Such systems require frequent breaching of sandbars to ensure suitable rearing conditions. In a lagoon, good water quality develops when the system is converted to fresh water, which results in lower water temperatures and higher bottom DO levels. Infrequent breaching, especially during low-flow summer months, impairs water quality because salinity stratification results in higher water temperatures and low DO levels (Smith 1990).

Because management of the Estuary under baseline conditions does not allow lagoon formation, the monitoring programs did not address what water quality would be like under a natural estuarine/lagoon cycle.

Under the proposed project, inflow to the Estuary would be reduced during the summer months and managed so that after the sandbar forms, the lagoon would be maintained at a WSE of approximately 8 to 6 feet at the Jenner gage. The lagoon would reach an equilibrium situation in which outflow through the sandbar equals inflow from the river. While deep saltwater pools in the bottom layers might remain, it is likely there would be more surface area and more shallow freshwater habitat, better water quality, and increased productivity, than currently exists under the baseline management scenario. Therefore, the Estuary could be managed as a closed lagoon system.

Potential water quality problems could exist under such a scenario. In November 1992, anoxic water from Willow Creek was flushed into the Estuary when the sandbar was breached at a water level over 9 feet (RREITF 1994). This could have been caused by a flush of anoxic sediments. Alternatively, poor water quality could have formed when vegetation was submerged by high water levels and began to decay. However, with stable WSE, aquatic vegetation could establish and summer water quality in Willow Creek could potentially improve. Finally, agricultural runoff and treated sewage discharge may increase nutrient levels in the Estuary. Reduced river flow in the lower river may reduce dilution of these nutrients.

Part of Merritt Smith Consultants' (MSC) and SCWA's 5-year monitoring effort has focused on Willow Creek. In 1992, a fish and invertebrate kill was associated with a flush of anoxic water from Willow Creek after the sandbar was breached when water levels were over nine feet. At high water levels, larger areas of the marsh in Willow Creek are inundated, and a large water volume may have become anoxic. This kind of event has not occurred during 5 years of monitoring in the Estuary (MSC 2000). Mortality of prickly sculpin in 1998, associated with a breaching event after water levels rose to 8.2 feet, may have been caused by low DO in water draining from Willow Creek, but no anoxia was detected (MSC 1998). Dead dungeness crabs were found in 1999 near the mouth of Willow Creek, but this was most likely due to a flush of fresh water after an artificial breaching event (MSC 2000). Artificial breaching of the sandbar is currently conducted at lower water elevations on the Jenner gage. Breaching below approximately 7 feet at Jenner appeared to prevent the outflow of anoxic water from the creek.

C.1.11.3 EVALUATION CRITERIA FOR WATER QUALITY

Infrequent artificial breaching during the dry season would impair water quality. Optimal water quality conditions would result if the sandbar were to remain closed and the lagoon were allowed to convert to freshwater conditions. If inflow to the lagoon were high enough to cause flooding of local property and an artificial breaching were needed, frequent breaching would be needed to limit the duration and intensity of poor water quality events.

C.1.11.3.1 Sandbar Open

Biological and water quality monitoring in the Estuary over a 5-year period shows that water quality begins to deteriorate immediately after the sandbar forms. When the sandbar opens, tidal flushing can result in improved water quality. Evaluation criteria for water quality under an open sandbar management strategy are based on the assumption that limiting the amount of time the sandbar remains closed following a closure event would limit the severity and length of poor water quality events (Table C-69). A score of 5 is given to a breaching schedule that ensures the sandbar is not closed for more than 5 days. Sandbar closed episodes during the monitoring study occasionally exceeded 10 days, and it is estimated that in general, closure of the sandbar for longer than 14 days may result in water quality conditions that are detrimental for salmonids. Longer periods of time are given lower scores.

Table C-69 Water Quality Evaluation Criteria — Sandbar Open

Category Score	Frequency of Artificial Breaching (Time Sandbar Remains Closed)
5	0 – 5 days
4	6 – 10 days
3	11 – 14 days
2	15 – 21 days
1	> 22 days < 40 days

C.1.11.4 REARING AND MIGRATION

Estuaries and lagoons provide important rearing habitat for salmonids. Smaller lagoons in the Central California Coast Steelhead ESU and small lagoons north of the Russian River have been shown to provide important rearing habitat for steelhead in the summer (Smith 1990, Larson 1987, Anderson 1995, 1998, 1999, Cannata 1998). Because they are food-rich, lagoons can contribute substantially to juvenile growth, which can translate into increased return rates for adults (Smith 1990).

Lower river environments in the north (most of which are estuaries open to tidal mixing) also provide important habitat for Chinook salmon fry or fingerling rearing (Reimers 1973, Levy and Northcote 1982, Kjelson et. al 1982, Simenstad 1982, Anderson and Brown 1982, Meyers and Horton 1982, Groot and Margolis 1991). Reimers (1973) demonstrated that Chinook salmon exhibiting a life-history strategy that remained in fresh water until early summer, then reared for a period of improved growth in the Estuary, represented approximately 90 percent of the returning spawners in the Sixes River, Oregon. In the Sacramento-San Joaquin River estuary, Chinook salmon fry rear in freshwater habitat within the upper delta before moving into the estuary as smolts (Kjelson et al. 1982).

Juvenile salmonid rearing is generally thought to occur during the following times:

- Coho Salmon — All year, generally rear in tributaries
- Steelhead — All year
- Chinook Salmon — February through June

Salmonid survival necessitates their ability to pass through the river mouth and Estuary during migration periods, and that water quality is high during passage. Artificial breaching provides more passage opportunities than would occur under natural conditions. A key consideration is whether water quality is sufficient when additional passage occurs.

When the rainy season begins, the sandbar generally opens naturally. Rain and increased flow at this time would create good passage conditions for adults migrating upstream. The peak adult Chinook salmon spawning run begins after November, although Chinook salmon begin to gather outside of the river in mid-August.

Adult migration periods for salmonids are:

- Coho Salmon — November through January
- Steelhead — January through March
- Chinook Salmon — Mid-August through January, with peaks occurring after November

Water quality in the Estuary is primarily dependent upon how long the sandbar is closed, and sandbar closure is primarily related to ocean and river flow conditions. Once the sandbar is breached, water quality does not immediately improve in the upstream parts of the Estuary, and the sandbar may close again before it does improve. Several successive breaching events may be required to improve water quality in upper reaches.

If the sandbar were to be breached before winter storms help improve water quality in the mainstem Russian River, adult Chinook salmon may not be able to pass, and may become trapped in poor quality water. Coho salmon and steelhead adults generally migrate later, and are more likely to move upstream when water quality has improved with higher flows.

Water quality evaluation criteria under Estuary management are applied for adult salmonid passage from August to the first significant rains. If the rains are very late, artificial breaching may provide passage during peak spawning times while water conditions could still be poor in the Estuary or the mainstem river. Anecdotal information may provide information on whether salmonids, particularly Chinook salmon, have been trapped anywhere in the river.

Smolt emigration is usually complete by early summer. If the sandbar were to close at some time in the late spring, artificial breaching would provide additional passage opportunities in addition to those that would have naturally occurred. This may benefit salmonids that have undergone the physiological changes that prepare them for saltwater conditions. Juvenile salmonid migration generally correlates to the occurrence of spring freshets, among other factors, and water quality at this time would be expected to be better than during the summer in the Estuary and the river. Emigration times for juveniles are:

- Coho Salmon — February through mid-May
- Steelhead — March through June
- Chinook Salmon — February through May

Water quality evaluation criteria under sandbar-open management are applied for juvenile migration in the spring (Table C-69). Furthermore, artificial breaching affects the amount of time a closed sandbar could delay juvenile outmigration.

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ATTACHMENT 1

WATER TEMPERATURE CRITERIA AND REFERENCES FOR SALMONIDS

Table A Water Temperature Criteria and References for Salmonid Upstream Migration

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Coho Salmon	Upstream Migration	0	1.7	< 3	ILT	Bjornn and Reiser
		1	3	< 4		
		2	4	< 5		
		3	5	< 6		
		4	6	< 7.2		after McMahon 1983
		5	7.2	12.7	Migration Range	Bjornn and Reiser, Wedemeyer 1970
		4	12.7	14		Burroughs, Bjornn and Reiser
		3	14	< 15		after McMahon 1983
		2	15	< 16		after McMahon 1983
		1	16	< 21.1		after McMahon 1983 with Hallock (1970) as an estimator
		0	21.1			Use Hallock as an estimator
Steelhead	Upstream Migration	0	4		No Migration	cited by Raleigh 1984
		1	4	5		
		2	5	6		
		3	6	7		
		4	7	7.8		
		5	7.8	11	Migration Range	CDFG 1991
		4	11	13		
		3	13	15		
		2	15	17		
		1	17	19		
		0	21.1		No Migration	Cramer 1992

Table A Water Temperature Criteria and References for Salmonid Upstream Migration (Continued)

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Chinook Salmon	Upstream Migration	0	<0.8		ILT	Bjornn and Reiser
		1	□3	> 0.8		
		2	≤ 5.2	>3		
		3	≤ 7.9	> 5.2		
		4	≤ 10.6	> 7.9		
		5	> 10.6	≤ 15.6	Migration Range	Bjornn and Reiser
		4	> 15.6	≤ 17.0		
		3	> 17.0	≤ 18.4		
		2	> 18.4	≤ 19.8		
		1	> 19.8	≤ 21.1		
		0	>21.1		No Migration	Hallock 1970, Cramer 1992

Table B Water Temperature Criteria and References for Salmonid Spawning

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Coho Salmon	Spawning	0	1.7		ILT	Bjornn and Reiser
		1	1.7	3		McMahon 1983
		2	3	4		
		3	4	6		
		4	6	7		McMahon 1983
		5	7	13	Columbia	EPA 1974
		4	13	14		McMahon 1983
		3	14	15		
		2	15	16		
		1	16	17		
		0	17			McMahon 1983
Steelhead	Spawning	0		4	No migration criteria	Hanel (1971) McMahon 1983
		1	4	5		
		2	5	6		
		3	6	7		
		4	7	7.8		
		5	7.8	11.1	American River	CDFG 1991 Rich 1987
		4	11.1	14	embryos	Raleigh et al. 1984
		3	14	16		
		2	16	18		
		1	18	20		
		0	20		unsuitable	Raleigh et al. 1984

Table B Water Temperature Criteria and References for Salmonid Spawning (Continued)

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Chinook Salmon	Spawning	0		1	embryo survival	Seymour(1956)
		1	1	2.5		
		2	2.5	3.5		
		3	3.5	4.5		
		4	4.5	5.6		McMahon 1983
		5	5.6	13.9		Bjornn and Reiser Bell (1986)
		4	13.9	14.5		
		3	14.5	15.2		
		2	15.2	16		
		1	16	16.7		
		0	16.7		embryo survival	Boles 1988

Table C Water Temperature Criteria and References for Salmonid Incubation (Continued)

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Coho Salmon	Incubation	0		0		McMahon 1983
		1	0	3		McMahon 1983
		2	3	3.5		McMahon 1983
		3	3.5	4		McMahon 1983
		4	4	4.4		McMahon 1983
		5	4.4	13.3		Bjornn and Reiser Bell (1986)
		4	13.3	14		McMahon 1983
		3	14	15		McMahon 1983
		2	15	16		McMahon 1983
		1	16	18		McMahon 1983
		0	18			McMahon 1983
Steelhead	Incubation	0		1.5	unsuitable	Raleigh et al. 1984
		1	1.5	3		
		2	3	4.5		
		3	4.5	6		
		4	6	7.8		
		5	7.8	11.1	American River	CDFG 1991 Rich 1987
		4	11.1	13		
		3	13	15		
		2	15	17		
		1	17	20		Raleigh et al. 1984
		0	20		unsuitable	Raleigh et al. 1984

Table C Water Temperature Criteria and References for Salmonid Incubation

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Chinook Salmon	Incubation	0		1	No survival	Raleigh et al. 1986 Seymour (1956)
		1	1	2		
		2	2	3		
		3	3	4		
		4	4	5		
		5	5	12.8		Boles et al. (1988) Seymour (1956)
		4	12.8	14.2	Sacramento River, 10 percent Mortality	Resources Agency (1989)
		3	14.2	15		
		2	15	15.8		
		1	15.8	16.7		
		0	> 16.7		Sacramento River, 100 percent mortality	Resources Agency (1989) Boles(1988)

Table D Water Temperature Criteria and References for Salmonid Rearing

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Coho Salmon	Rearing	0	1.7		ILT	Bjornn and Reiser Brett (1952)
		1	1.7	4		
		2	4	7		
		3	7	8		
		4	8	12		McMahon 1983
		5	12	14	preferred	Bjornn and Reiser Brett (1952)
		4	14	15		McMahon 1983
		3	15	16		McMahon 1983
		2	16	20		McMahon 1983
		1	20	26		McMahon 1983
		0	26		ILT	Bjornn and Reiser Brett (1952)
Steelhead	Rearing	0	0		ILT	Bjornn and Reiser Bell (1986)
		1	0	2		Raleigh 1984
		2	2	4		
		3	4	8		
		4	8	12.8		
		5	12.8	15.6	American River Rearing	CDFG 1991 Rich 1987
		4	15.6	18		
		3	18	20		
		2	20	22		
		1	22	23.9		
		0	23.9		ILT	Bjornn and Reiser Bell (1986)

Table D Water Temperature Criteria and References for Salmonid Rearing (Continued)

Species	Lifestage	Category	Temperature (°C)		Criteria	References
Chinook Salmon	Rearing	0	1		ILT	Bjornn and Reiser Brett (1952)
		1	1	4		
		2	4	6		
		3	6	8		
		4	8	12		
		5	12	14	preferred	Bjornn and Reiser Brett (1952)
		4	14	17		
		3	17	20		
		2	20	23		
		1	23	26		Raleigh 1986
		0	26		ILT	Bjornn and Reiser Brett (1952)

APPENDIX D

PRELIMINARY RECREATION ASSESSMENT FOR THE FLOW PROPOSAL

PRELIMINARY RECREATION ASSESSMENT FOR THE FLOW PROPOSAL

Prepared for:

SONOMA COUNTY WATER AGENCY

Santa Rosa, California

Prepared by:

ENTRIX, INC.
590 Ygnacio Valley Road
Walnut Creek, CA

Project No. 3064703

January 16, 2004

PRELIMINARY RECREATION ASSESSMENT FOR THE FLOW PROPOSAL

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Attachments

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Term	*Definition*
ASR	aquifer storage and recovery
BA	Biological Assessment
CDFG	California Department of Fish and Game
cfs	cubic feet per second
D1610	Decision 1610
DWR	Department of Water Resources
ESA	Federal Endangered Species Act of 1973
Estuary	Russian River Estuary
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
NEA	Northwest Economic Associates
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries (formerly NMFS)
PG&E	Pacific Gas and Electric Company
PPFC	Public Policy Facilitation Committee
RREITF	Russian River Estuary Interagency Task Force
RV	Recreational Vehicle
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers
WSTSP	Water Supply and Transmission System Project

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1.1 INTRODUCTION

The U.S. Army Corps of Engineers (USACE), the Sonoma County Water Agency (SCWA), and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the federal Endangered Species Act (ESA) with National Oceanic and Atmospheric Administration Fisheries (NOAA Fisheries, formerly National Marine Fisheries Service [NMFS]) to evaluate the effects of their operations and maintenance activities on listed species and their critical habitat.

This consultation addresses the effects of project operations on coho salmon, steelhead, and Chinook salmon in the Russian River watershed in Sonoma and Mendocino counties. USACE, SCWA, and MCRRFCD operate and maintain facilities and conduct activities related to flood control, hydroelectric power generation, water supply and diversion, instream flow, estuary management, channel maintenance, restoration, and fish production. In addition, these agencies are participants in a number of institutional agreements related to fulfilling their respective responsibilities.

As a part of the Section 7 Consultation, the USACE has developed a Biological Assessment (BA) that provides a project description identifying ongoing actions and describing the proposed changes to facilities, operation, and maintenance activities. Under the proposed project, USACE, SCWA, and MCRRFCD would continue to implement many activities that occur under baseline conditions. Modifications to existing operations would be made to benefit protected anadromous fish species. One of the changes proposed in the BA is a new water management proposal called the “Flow Proposal.” The Flow Proposal would lower flows in Dry Creek and the Russian River to provide better rearing conditions for young salmon and steelhead. Proposed changes to summer flows in the Lower Reach of the Russian River (“Lower Reach”) could affect recreational uses.

This document is a preliminary assessment of river-based recreation opportunities under the Flow Proposal presented in the BA. It includes a description of the existing conditions pertaining to swimming and paddling use on the Lower Reach. It also describes, on a larger scale, the variety of recreation opportunities that exist in the Russian River region (within several miles on either side of the river) from Healdsburg to Jenner. Finally, this document discusses changes in canoeing use and other recreation uses that may occur under the proposed project. Economic effects associated with changes in canoeing use are described in the *Economic Analysis for the Russian River Biological Assessment* (Appendix E), prepared by Northwest Economic Associates (NEA).

1.2 OBJECTIVES OF RECREATION STUDY

Social and economic aspects related to the Flow Proposal were discussed at two Public Policy Facilitating Committee (PPFC) meetings in 2002. The Flow Proposal could have both positive and negative impacts on the regional economy. A positive economic impact could result from construction of a pipeline from Warm Springs Dam to Dry Creek, the Wohler diversion facility, or a treatment plant. Construction of the pipeline would create jobs in construction and related economic sectors. A negative economic impact could result from decreased use of commercial facilities that rent canoes and watercraft. This recreation study, focused on the Lower Reach of the Russian River, examines existing recreation use for a variety of water-related and non-water-related recreation activities.

The recreation study objectives are to:

- Identify recreation opportunities in the study area from Healdsburg to Jenner, which represents a distinctive destination for outdoor recreation within the larger project area for which the BA was written.
- Examine current recreation use in the Lower Reach and, as a secondary objective, provide recreation use data as input to the economics study.
- Discuss how recreation opportunities might change as a result of changes in the Flow Proposal.

The recreation study provides recreation use data for the economic study. The economic study has two purposes: 1) to examine the effects of changes in the Russian River Flow Proposal on recreation trip-related spending and hydropower generation revenue for Sonoma and Mendocino counties; and 2) to examine secondary economic impacts. Independent of the recreation study, the economic study examines effects of the flow on reservoir levels at Warm Springs and Coyote Valley dams and pool-level variations on recreation attendance at those locations. This attendance information is modeled to estimate economic impacts to Sonoma and Mendocino counties. The complete report of the economic study is found in the aforementioned Appendix E of the 2004 Russian River BA prepared by NEA for SCWA.

1.3 RECREATION STUDY AREA

The recreation study area encompasses the Russian River corridor beginning at Healdsburg and ending at Jenner. The recreation area is smaller than both the study area described in the 2004 Russian River BA and the study area for the economic impact study.

The Russian River drains a watershed of nearly 1,500 square miles centered 60 miles northwest of San Francisco, and empties into the Pacific Ocean near Jenner. The Russian River flows southward from its headwaters through small valleys and past the cities of Ukiah, Hopland, and Healdsburg before turning west at Mirabel Park. Joining the river near that point are flows from Mark West Creek and Laguna de Santa Rosa, which drain much of the southern portion of the basin. From Mirabel to the Pacific Ocean, low mountains along both banks confine the river for 22 miles. Major tributaries of the Russian River include the East Fork, Big Sulphur Creek, Maacama Creek, Dry Creek, and Mark West Creek/Laguna de Santa Rosa.

1.3.1 Lower Reach Russian River

Downstream of the Wohler Bridge, the Russian River flows westerly through a narrow valley bounded by mountains. The channel is straight and deep with a low floodplain in the area of Guerneville, which is situated on the north side of the river. Guerneville is subject to frequent flooding, averaging a flood once every 5 years (EIP 1993). Gravel and sandbars are common along the channel. Below Guerneville, the Lower Reach flows into the Russian River Estuary (Estuary) near the confluence with Willow Creek.

1.3.2 Estuary

The Russian River Estuary (Estuary) near Jenner extends approximately 6 to 7 miles from the river's mouth at the Pacific Ocean, upstream to Duncans Mills and Austin Creek in western Sonoma County. Tidal influence has occurred as far as 10 miles upstream to Monte Rio (Russian River Estuary Interagency Task Force [RREITF] 1994). A barrier beach (sandbar) forms naturally across the mouth of the river periodically during the dry season, impounding water and forming a lagoon. The sandbar opens naturally when hydraulic conditions in the Russian River and Pacific Ocean change, or when it is artificially breached. When the sandbar is open, the Estuary is open to tidal mixing.

1.4 Flow Management

Analyses reported in Chapter 5 of the 2004 Russian River BA indicate that the habitat for listed fish species could be improved by decreasing summer flows. Under the proposed project, releases from Warm Springs and Coyote Valley dams would be modified to:

- Reduce summer water velocities in Dry Creek and the Upper Russian River.
- Conserve the coldwater pool in Lake Mendocino through the late summer.
- Provide for the exercise of existing water rights in the Russian River and Dry Creek.
- Enable SCWA to meet future transmission system demands arising from approved developments in SCWA's water contractor's service areas.
- Allow the sandbar at the mouth of the Russian River to be closed in the summer.

The most substantial changes to flow would occur in summer (June to September). During that period, the Flow Proposal would meet water supply needs, improve summer rearing habitat in the Upper Russian River and Dry Creek for listed fish species, and allow the mouth of the river to close, thereby providing more consistent estuarine rearing conditions. To implement the Flow Proposal, minimum instream flows during the summer in the Russian River downstream of Coyote Valley Dam, and in Dry Creek downstream of Warm Springs Dam would be lower than those currently in effect under State Water Resources Control Board (SWRCB) Decision 1610 [D1610 (SWRCB 1986)]. Monthly median flows in the Russian River under D1610 and the proposed project are summarized in Table 1-1 below.

Table 1-1 Monthly Median Flow Exceedance Levels under D1610 Scenario and the Flow Proposal under All Water Supply Conditions and Existing Demand

Gage	June		July		August		September		October	
	D1610	Flow Proposal	D1610	Flow Proposal	D1610	Flow Proposal	D1610	Flow Proposal	D1610	Flow Proposal
Healdsburg	237	181	208	119	200	128	164	126	169	141
Hacienda Bridge	279	188	197	78	174	68	148	78	163	119

The water supply "condition" is determined each year based on cumulative inflow to Lake Pillsbury on the first of each month between January and June, and is represented as *critically dry*, *dry*, or *normal* (SWRBC 1986).

Under D1610 requirements, the median flows at Healdsburg range from 237 cfs in June to 164 cfs in September. Under the Flow Proposal, the median flows range from 181 cfs in June to 126 cfs in September. Flows show the same pattern for Hacienda Bridge; the highest flows occur in June, flows decline through September, and flows increase in October.

SCWA would develop additional measures to meet future water supply demands while limiting releases to maintain suitable rearing habitat for young fish. The primary measures under consideration are: an aquifer storage and recovery (ASR) program; a pipeline from Warm Springs Dam to the mouth of Dry Creek, the Wohler diversion facility, or a treatment plant; and/or additional storage facilities (ENTRIX, Inc. 2004). Reduced flow to the Estuary would reduce the need to artificially breach the sandbar during the summer (ENTRIX, Inc. 2004). This action is expected to improve salmonid summer rearing habitat in the Estuary. Artificial breaching would still be required to manage storm flow and prevent flooding to private property and roads during the rainy season.

2.1 OVERVIEW

A combination of existing recreation use information and user surveys were used to assess recreation opportunities in the Lower Reach.

The process of data collection consisted of several key tasks. The first task involved a literature review of recreation studies in California pertinent to the Lower Reach. The second task involved personal interviews, asking respondents about the typical visitor on the Lower Reach, use levels on the river, and users' flow preferences. These topics were asked of three groups: 1) public recreation agency personnel, including Chamber of Commerce staff, 2) individual, regular paddlers of the Lower Reach; 3) business owners or operators, and. Surveys were tailored for each of the three groups (see Attachments 1 through 3). A third task consisted of a site visit to assess current paddling and swimming conditions.

2.2 DATA COLLECTION

2.2.1 LITERATURE SEARCH

A literature review was conducted to: 1) characterize the existing recreation setting in the study area; and 2) understand the types of recreation opportunities available in the recreation study area. Characterizing the recreation setting involved Internet searches, consulting guidebooks and trade publications, and surveying local business owners/operators and regular paddlers of the Lower Reach.

Several published resources were identified and consulted by researchers (California Department of Water Resources 2002; PG&E 2001; Dwyer 2000; Stienstra 2000; California Department of Parks and Recreation 1998; Shelby et al. 1997; California State Coastal Conservancy 1996; Whittaker et al. 1993; Shelby et al. 1992; Brown et al. 1991; Moore et al. 1990).

These published documents included a statewide study of California's recreation preferences and unmet demand, and a study of recreation use on another Northern California river used for recreation, as well as numerous peer-reviewed studies describing aspects of river recreation pertinent to those of concern in this study.

Literature reviews of recent recreation use, guidebooks, Internet searches, trade publications, and other peer-reviewed recreation studies were evaluated to develop an understanding of existing conditions in the Lower Reach.

Existing and estimated recreation use levels were provided by Sonoma County Regional Parks and the Russian River Chamber of Commerce.

The survey respondent information (interviews) and the site visit were conducted to supplement the published resources.

2.2.2 Data From Local Agencies

Several agencies collect data pertinent to the recreation use in the Lower Russian River. Agencies contacted included representatives from the Monte Rio Parks and Recreation District, Sonoma County Regional Parks, and the Russian River Chamber of Commerce. Other agencies such as U. S. Army Corps of Engineers, California Department of Fish and Game (CDFG, and California Department of Parks and Recreation were also contacted for regional recreation use information. The interviews conducted with local agencies utilized a series of scripted questions. The survey form is provided in Attachment 1.

Agency staff provided information included the Monte Rio Parks and Recreation District, Sonoma County Regional Parks, CDFG, and the Russian River Chamber of Commerce. Specific to the agency staff survey, agency staff were asked about the level of day versus overnight users who boat on the Lower Reach, to ascertain any differences in users' activity, and if there was a specific measure of individual visits. CDFG agency staff were specifically asked about the level of demand for salmonid and bass fishing.

2.3 Supplemental Recreation Survey of Individuals and businesses

To supplement the information collected from state and local agencies and that found in published sources, ENTRIX surveyed recreational users and local businesses. The primary purpose of the surveys was to generally characterize the existing recreation environment. The surveys were designed as a qualitative data set providing researchers with information characterizing the general recreation patterns in the Lower Reach area. They were not intended to produce a statistically complete sample of survey respondents.

The surveys were conducted by phone and the surveyor asked a series of scripted questions. The questions focused on recreational use of the Lower Reach. Content for the three surveys was developed based on other surveys used for water projects throughout Northern California, and from several discussions between SCWA, ENTRIX, and NEA staff.

2.3.1 Survey Design

An initial list of potential contacts was developed by ENTRIX, NEA, and SCWA. Additional participants were identified through a "snowball" technique, commonly utilized by ethnographic researchers. This focus group research method builds on community networks and knowledge, beginning with the identification of one person (or persons) who represent a particular interest (PG&E 2001, Babbie 2001). Attachment 5 provides the list of individuals and businesses contacted as a part of this survey. The goal was to survey 10 recreational paddlers and: 10 business owners/operators. If the survey could not be competed by phone, the survey participants had the opportunity to complete the interview form by mail. The survey forms used for the recreation users and the local businesses are provided in attachments 2 and 3 respectively. All of the recreation users completed the survey and of the 10 businesses contacted, 9 completed the survey.

Specific to the recreation user survey, regular paddlers were asked about their place of residence, level of boating experience, number of times they have boated on the Lower Reach, and use of shuttle services.

Businesses surveyed included owners/operators of boat rental companies, sporting good stores and lodging establishments. During the survey, business owners/operators were asked why their customers visit the Lower Reach, and whether their customers would still visit the Lower Reach if flows were low. Business owners/operators were then asked if any of the following would encourage their customers' use of the Lower Reach during low flows: portage services, inflatable watercraft, special timing of releases, or other activities or services. Business owner/operators were asked about their canoe fleet size, if applicable, or the number of beds/campsites offered by their establishment. Also, business owners were asked to voice any other concerns they may have had about the flow proposal.

In addition to this effort, ENTRIX conducted several open-ended interviews with resort lodging owners/operators to obtain additional information on what attracts visitors to the recreation study area, and to ensure that a wide range of possible recreation activities were identified. Finally, an email survey was prepared as requested by the Russian River Chamber of Commerce. The interview form was reformatted so that it was easy for those completing the surveys to do so without assistance from an interviewer. These reformatted surveys were provided to Russian River Chamber of Commerce for distribution to the approximately 200 members and ENTRIX is looking forward to receiving the results. Copies of the email surveys are provided in Attachment 4.

2.3.2 DATA ANALYSIS

Current swimming use was estimated based on beach attendance data provided by Sonoma County Regional Parks. No estimates were available for paddling use. A preliminary estimate of paddling use was developed based on information provided by the regular users of the Russian River (see Attachment 6). Because there was high variation in the estimates provided by regular river users, medians are reported rather than means.

Total paddling use and swimming use for a typical recreation season were then estimated for D1610 flows and for the Flow Proposal flows. Paddling opportunity was restricted to days when flows in the Russian River were greater than 140 cfs (see attachment 6).

Frequency distributions generated for the survey questions are reported in Attachment 7.

2.4 SITE VISIT

ENTRIX staff conducted a site visit of the recreation study area from Guerneville to Jenner. The objective of the site visit was to evaluate the recreational experience for the perspective of a first time visitor to the Russian River who came with the express purpose of canoeing the Lower Russian River. Recreation planners unfamiliar with the Russian River conducted the site survey. The site visit evaluated the ease of finding put-in and take-out sites and river conditions affecting a typical canoeing experience on the Lower Russian River.

The following section describes study results, including the supply of existing recreation opportunities in the study area, the existing uses for paddling, swimming, beach use, and sportfishing, and finally, recreation opportunities that could occur under the Flow Proposal.

3.1 EXISTING OPPORTUNITIES (SUPPLY)

The Lower Reach is characterized by coastal forests, private resorts, and public access to the river. The available recreational opportunities are categorized as river-related and non-river-related opportunities. This information was obtained through Internet research and personal communication with local entities such as the Russian River and Healdsburg Chambers of Commerce, and rental businesses, lodges and resorts in the area. The topics included the peak tourist season, recreational activities in the Lower Reach area including boating and swimming, and the origin of visitors. Boat rental businesses were consulted about the total number of boats available for rent and possible river access points for launching and taking out boats. On-site information was also obtained from the June 2, 2003 site visit and canoe trip.

3.1.1 RIVER-RELATED OPPORTUNITIES

Major river-related recreational activities include boating (canoeing and kayaking), swimming, and sport fishing.

3.1.1.1 Boating

Approximately 380 boats are available in the project area at various rental businesses including Trowbridge Canoe Trips, SOAR Inflatables, and Kings Coast and Kayak. Although not confirmed with staff at Burke's Canoes, anecdotal evidence suggests that another 300 canoes may be available at Burke's, increasing the total number of commercial watercraft to 680 for the project area. Kayak and canoe trips typically travel from town to town along the Lower Reach; for example, from Healdsburg to Guerneville, Healdsburg to Forestville, or Forestville to Jenner.

According to Bob Clemens of Trowbridge Canoe Trips (pers. comm. June 2003), a typical put-in location for the Lower Reach is at Healdsburg. The estimated high level of flow obtained from the Healdsburg gage was 800 cubic feet per second (cfs); the lowest level was 90 cfs. Ideally, the lowest flow for boating is 150 cfs, to avoid scraping and dragging the watercraft (Bob Clemens, pers. comm. 2003). Recently, Sonoma County has developed parks and put-in and take-out sites that provide for additional river access and trip length options. Dwyer (2000) lists two reaches; Healdsburg to Guerneville, and Guerneville to Jenner Beach. For the first reach, Dwyer indicates a put-in location at Healdsburg Veterans Memorial Park, and a take-out location at Johnson's Beach. For the second reach, Dwyer lists the put-in location as Johnson's Beach, and take-out locations at the public boat ramp at Jenner.

In addition to paddling opportunities on the Lower Reach, there are numerous regional opportunities in Sonoma and Mendocino counties (Dwyer 2000). Two examples of regional paddling opportunities include:

- Austin Creek, traversing for 7.5 miles and rated as Class 1+. Although not available in summer, the best recreational seasons are winter and spring, and the advantageous flow rate ranges from 300 to 1,000 cfs (Dwyer, 2000). Austin Creek is rain fed and has a tendency to experience high-water levels. Fallen trees and other natural debris are common in the water and on the banks. There is also a high population of camps along the shore during the summer.

- The Wheatfield Branch of the Gualala River, spanning approximately 27 miles, and rated as Class 1 to 1+. The most advantageous boating and recreation seasons are spring and early summer, and the best flows range from 250 to 600 cfs. The river is close to the ocean, and cold weather is common. This weather, combined with a redwood forest in the vicinity, creates foggy conditions. Conditions are generally uncrowded, and there are good opportunities to observe wildlife. Fallen trees and other natural debris are commonly found in the water. The majority of the river flows through private land with limited access.

3.1.1.2 Swimming

Swimming is common in beach areas such as Healdsburg Veterans Memorial Beach, Monte Rio Beach, and Johnson's Beach at Guerneville. Camping and recreational vehicle (RV) park sites in close proximity to the river (e.g., at Monte Rio Beach and Johnson's Beach in Guerneville) provide easy access to swimming and beach activities. Reservoir-related swimming activity is described in the Appendix E economics report.

3.1.1.3 Camping and Lodging

Several campsites and RV park sites along the Russian River facilitate recreational activities such as canoe and kayak rentals. These include Casini's Campground near Jenner and Mirabel RV Park in Forestville, as well as facilities at Monte Rio Beach and Johnson's Beach in Guerneville.

Bob Clemens of Trowbridge Canoe Trips (pers. comm. June 2003) stated that at least 90 percent of the visitors are from outside the Lower Reach area, and that 40 percent of the Lower Reach area visitors stay overnight.

The Lower Reach area has a large number of lodges and resorts that cater to overnight visitors. Steve Fogle of the Russian River Chamber of Commerce (pers. comm. 2003) estimates the total occupancy (i.e., the total number of rooms or beds in the local hotels, resorts, retreats, and cottages) at approximately 880 per night. In addition, approximately 230 campsites are available (Russian River and Healdsburg Chamber of Commerce websites, 2003).

3.1.2 Non-River-Related Opportunities

In addition to river-related recreational activities, the project area offers various non-river-related activities such as coastal exploration, farmer's markets, festivals, parades, and other public events in several towns near the Lower Reach. Activities such as camping and hiking occur in the Armstrong Redwoods State Reserve. Golfing, visiting galleries and shops, and wine tasting attract visitors throughout the year. In the local region, more than 150 festivals and events occur annually (Russian River Chamber of Commerce 2003).

Proprietors of local resorts and lodges were interviewed for information on non-river-related recreational opportunities. According to Rick Reese at the Willows in Guerneville (pers. comm. June 4, 2003), most of the tourists come to the Lower Reach area from the Bay Area, with the peak season spanning from May through October.

According to Karina Ramirez at Creekside Inn and Resorts (pers. comm. June 16, 2003), most tourists come to the Inn from Bay Area locations such as San Francisco, Oakland, and Alameda. The principal destination for river use is from Guerneville to Jenner. According to Ms. Ramirez, one of the main reasons for visiting the Lower Reach area is the peace and quiet.

Sandy Brown of the Russian River Chamber of Commerce (pers. comm. June 17, 2003) and Carla Martinez (pers. comm. June 17, 2003) said that the height of the tourist season is from May through October.

Russ Pugh (pers. comm. 2003), an event organizer in the Russian River area, provided information on annual public events that attract thousands of visitors to the area. The events include two triathlons, the Vine Man Event (early August), and the Half Vine Man Event (mid-August). These events draw approximately 10,000 visitors that arrive from various locations throughout California and the United States. Most visitors stay overnight at local resorts and lodges and add to the local economy. The swimming portion of this event takes place at the Johnson's Beach and is river-dependent.

3.2 Existing Use Levels (Demand)

The following section describes the existing use levels (public demand) for the Lower Reach.

3.2.1 Paddling

Recreational paddlers with the most experience paddling on the Lower Reach originate from Guerneville and Healdsburg. Several portions of the Lower Reach are popular paddling locales—for example, Healdsburg to Guerneville, Forestville area, Healdsburg to Steelhead Beach, and Duncans Mills to Jenner.

Several sources including published literature, guidebooks, professional judgement, and supplemental interview data indicate that watercraft use on the Lower Reach is based on several factors: warm weather encourages a greater number of visitors and greater river use, the availability of public access or put-in and take-out points for canoes and kayaks, and proximity to the river (frequency is greater when the proximity to the river is closer). There are a greater number of visitors during the summer and fewer during the winter months. The number of visitors/watercraft increases in late spring and summer.

Watercraft or beach use varies with the river location. For example, the town of Jenner is located at the southern tip of the Russian River near the ocean. The weather at this location is foggier and generally cooler than other towns along the river. Watercraft and beach use near Jenner is generally lower than at other Lower Reach locations. The overall watercraft use levels) indicate significant increases from weekdays to weekends to holidays.

3.2.2 BEACH USE AND SWIMMING

Verifiable beach use and swimming data were provided by Bert Whitaker of Sonoma County Regional Parks. Although anecdotal data were obtained on beach and swimming use, these data are not presented in this report because: 1) they appear to grossly underestimate use; and 2) they were not obtained in a verifiable, systematic manner.

Table 3-1 displays beach attendance for four beaches. Data were collected by automatic traffic counters, assuming an average of three persons per vehicle (Bert Whitaker, pers. comm. May 30, 2003). With the exception of Healdsburg, all beaches show steady increases in annual attendance. Steelhead Beach shows the largest percentage increase in use and the highest total number of visitors reported during the 2001-2002 season. The beach at Healdsburg has recently restricted use. It does not open until late June as a result of an agreement made with California Department of Fish and Game.

Table 3-1 Annual Beach Attendance, 1994 to 2002

Beaches	1994-1995	1995-1996	1996-1997	1997-1998	1998-1999	1999-2000	2000-2001	2001-2002	Totals
Steelhead	0	0	19,108	50,847	39,657	81,258	87,077	88,000	365,945
Healdsburg	81,853	94,268	73,612	58,060	75,028	70,171	56,437	34,000	543,249
Forestville Access	18,600	11,300	12,500	11,355	16,998	22,539	17,889	25,900	137,081
Wohler Bridge	14,643	21,803	32,389	26,695	41,354	30,092	36,785	39,500	243,261
Totals	115,096	127,371	137,609	146,957	173,037	204,060	198,188	187,400	1,289,718

Source: Sonoma County Regional Parks. (2003)

3.2.3 SPORT FISHING

Sport fishing is another river-related recreational activity popular throughout most of the year. The Lower Reach accounted for 7.5 percent of state steelhead fishing trips between 1993 and 1995, based on steelhead restoration program cards that were completed for fishing trips along the Russian River (Terry Jackson, pers. comm. May 16, 2003). In 1999, there were 454 steelhead-fishing trips on the Russian River and its tributaries out of 7,883 statewide steelhead-fishing trips, again based on steelhead restoration program cards (Terry Jackson, pers. comm. May 16, 2003). This number represents 5.76 percent of all 1999 state of California steelhead fishing trips, for which steelhead restoration program cards exist.

Due to uncertainties regarding the proportion of total steelhead anglers that actually complete the cards, it is not possible to accurately estimate the total steelhead fishing trips taken on the Russian River during 1999.

Summer fishing on the Lower Reach occurs for smallmouth bass and catfish including small numbers of shad and striped bass (J. Emig, pers. comm. May 16, 2003). Fishing for steelhead accounts for 95 percent of the fish sought, with the remaining 5 percent being "other" fish species. The peak fishing season is from October through March, although fishing trips may occur throughout the year.

According to information obtained from Mike Swaney of the Fishing Guide Service (pers. comm. May 21, 2003), in the area from Healdsburg to Monte Rio, approximately 80 percent of the fishing enthusiasts using guide services (non locals) stay overnight; the remaining 20 percent are day-use anglers using guide services. Fishing for steelhead accounts for 95 percent of the fish sought, with the remaining 5 percent being other fish species. The peak fishing season is from October through March, although fishing trips may occur throughout the year (M. Swaney, pers. comm. May 21, 2003).

Regarding locals, Sean White of SCWA stated that the vast majority of anglers in the Lower Reach reside nearby and that a small percentage come to the area for day use and overnight angling experiences (S. White, pers. comm. December 23, 2003).

3.2.4 General Visitor Use Levels

The Russian River Chamber of Commerce and Korbel Winery collect data on the number of visitors that come to their establishments. These data are reported below (Table 3-2) to provide an indication of the overall visitation that the project area receives. Data on total visitor use for the study area were not obtained due to the difficulty in breaking apart data from larger geographic regions to fit with the recreation study area.

Table 3-2 Visitor Use Estimates

	2001	2002	2003 until June
Chamber of Commerce — Walk-Ins	20,751	16,291	5,104
Korbel Winery — Walk-Ins	33,766	27,521	8,559

Source: Russian River Chamber of Commerce (2003). Personal communication.

3.2.5 Lower Reach Survey Respondent Profile

Interviews were conducted to supplement literature reviews and use data to assess recreation opportunities (existing conditions) in the Lower Reach. The personal interview process included asking respondents about the typical visitor on the Lower Reach, use levels on the river, and users' flow preferences. These topics were asked of three groups: 1) individual, regular paddlers of the Lower Reach; 2) business owners or operators, including Chamber of Commerce staff; and 3) public recreation agency personnel. Surveys were tailored for each of the three groups (see Attachments 1 through 3).

3.2.5.1 Recreational Paddlers Survey

Ten recreational paddling users were interviewed to determine such attributes as the number of years of experience, the number of times they used watercraft on the Lower Reach, the days of the week they used watercraft, etc. Half (five) of the respondents live locally; three in Healdsburg, one in Jenner, and one in Guerneville. The remaining five respondents live outside the immediate locale but within the general project vicinity.

The average number of years of experience among the ten paddlers was approximately 31. The fewest number of years involved with watercraft on the Russian River was 20, and the greatest number was 45. The paddlers that reported the fewest and the greatest number of years involved with watercraft on the Russian River live in close proximity—Guerneville and Healdsburg, respectively. Of the five paddlers who live in the general area but not directly adjacent to the Russian River (Santa Rosa and Sebastopol), the average number of years of experience was 28.6 years.

The average number of times the ten paddlers canoed or used watercraft on the Lower Reach during their total period of use (average = 28.6 years) was 700 times; however, the median use was only 135 times. The fewest number of times canoeing or using watercraft on the Russian River was 12 times in 33 years. The greatest number of times canoeing or using watercraft on the River was 2,080 (approximately 2 days a week for 20 years). Paddlers who reported the fewest and greatest number of times using watercraft on the Lower Reach live nearby in Santa Rosa and Guerneville. Proximity to the river is strongly related to the amount of river use.

Of the ten paddlers, eight use non-fee shuttle services that consist of driving themselves or obtaining a ride with friends to put-in and take-out points. None of the survey respondents use a fee-based shuttle service for transport along the Lower Reach. Table 3-3 illustrates survey responses to the shuttle use question.

Table 3-3 Shuttle Use

Following are responses to the survey question, *"Please estimate the percent of your customers who use shuttle services [and] of those, what percent are paid?"*

Non-Fee Shuttle	Frequency	Percent
Yes	8	80
No	2	20
Friends/Drive Self	10	100
Fee-based Shuttle	0	0

The most popular places for watercraft use included Healdsburg to Jenner, Monte Rio to Jenner, Healdsburg to Forestville, Healdsburg to Steelhead Beach, Duncans Mills to Jenner, and the Mirabel area. The ten paddlers were asked to state the number of watercraft they observed on a typical weekday, weekend day, and holiday day during the summer, which was defined as May through October. Table 3-4 provides a summary of the number of site visits for watercraft use.

Table 3-4 Number of Individual Site Visits for Watercraft

Following are responses to the survey question, "*Approximately how much use by canoes and other watercraft is there on the section [of the river] you know best?"*

	Weekday	Weekend	Holiday
Mean	52.06	158.29	283.75
Standard Deviation	31.24	91.56	185.21
Median	49.00	200	280

The numbers were based on the number of kayaks and canoes that the individuals observed during different times and the average occupancy of the boats. The number of site visits roughly corresponds to the total number of people boating in the river, according to the responses given by the ten respondents surveyed. The mean weekend use is almost 3 times that of the weekday use, and the overall holiday use appears to be double the weekend use.

The average response for weekday watercraft use levels was slightly more than 52, with a standard deviation of approximately 31 and a median response of 49. The average response for weekend day-use levels was slightly more than 158, with a standard deviation of approximately 91 and a median response of 200. The average response for holiday-use levels was slightly more than 283, with a standard deviation of approximately 185 and a median response of 280.

3.2.5.2 Individual Paddlers' Responses to Specific Survey Inquiries

The ten respondents were asked specific questions; following is a summary of their responses.

Why did you choose this destination?

Responses to this inquiry were divided into six categories to facilitate analysis and categorization of the participant's open responses. The categories include Aesthetics, Distance from Home, Good Flow, Nostalgia, No Crowds, and Other. Some of the responses were relevant to more than one of the categories, which explains why the percentages do not equal 100 percent. The most often cited reason for choosing the Lower Reach was aesthetics (30 percent), followed by the lack of crowds (20 percent), and good river flow (20 percent). Two paddlers stated that their reasons for choosing the Lower Reach were close proximity to home (10 percent) and nostalgic reasons (10 percent). Four of the responses fall within the other category: easy access (10 percent); play spots for recreational use (10 percent); convenient to local park (10 percent); and friends who live locally (10 percent).

What do you think are the most important attributes of the Lower Reach area?

The same six categories (Aesthetics, Distance from Home, Good Flow, Nostalgia, No Crowds, and Other) were used to categorize the respondents' answers to this inquiry. As mentioned above, many of the paddlers offered more than one response; thus, the percentages do not equal 100 percent. Half (five) of the ten paddlers stated that they used the recreational attributes of the Lower Reach because it was close to home. Three of the ten paddlers offered aesthetics as the most important attribute, and two stated that no crowd was the most important attribute. In the Other category, there was one response each for winter fishing, cooling off, swimming, sunbathing, fishing, and getting away from the city.

What is the main destination for watercraft users between Healdsburg and Jenner?

There was no single common reply among the ten paddlers. Several paddlers that completed an interview indicated that river flow and weather conditions are the primary factors in determining a destination. Responses to this query encompassed a relatively large geographical area between Jenner and north of Healdsburg. Following is a list of destinations, in no particular order. The paddlers often gave more than one destination, which may reflect how preferences for destinations are commonly based on flow and weather conditions for the particular day.

- Hacienda Bridge to Guerneville; Guerneville to Monte Rio.
- North of Healdsburg.
- Monte Rio to Jenner.
- Jenner to Duncans Mills.
- Jenner at high flow; Healdsburg to Walnut Bridge-Sunset Beach; as well as Sunset Beach, Guerneville, Monte Rio, Corbell, and Summer Bridge.

- Healdsburg to Jenner.
- A launch site near Memorial Beach; Steelhead Beach to the dam at Wohler; Duncans Mills to Jenner.
- Between Duncans Mills and Jenner.
- Steelhead Beach.

3.2.5.3 Watercraft and Recreation-Related Business Owners/Operators Survey

The following is a summary of nine local watercraft and recreational business owners/operators interviewed for this survey. The businesses are at various locales, with two each in Jenner and Healdsburg and one each in Santa Rosa, Duncans Mills, Windsor, Forestville, and Guerneville. The total number of years involved with recreation or watercraft in the area averaged 21 years; the lowest number of years was 3 and the highest was 46. The locales that correlated to greatest number of years of operation were Forestville (45) and Jenner (46). The business operations can be broken down into three basic categories: three offer guided watercraft tours, three manage beaches or campgrounds, and three rent watercraft such as kayaks and canoes. Seven of the nine business owner/operators said that none of their customers use the fee-based shuttle service. One respondent stated that 100 percent of the customers use the shuttle-based service but do not pay for it, and another respondent replied that approximately 90 percent of the customers use the fee-based service. The locations that the business respondents were most familiar with included, Healdsburg to Wohler Bridge, Healdsburg to Guerneville, Monte Rio, and Jenner and the surrounding area.

In addition to conducting surveys, several businesses were interviewed including two lodges and four rental businesses. The business owners/operators estimated that commercial river use was 50 to 80 percent, and that the majority of their business users were from the San Francisco Bay Area. The responses mentioned above can be divided into individual responses from each business surveyed. There was one response for 50, 70, and 75 percent, and one response for 75 to 80 percent. Five of the businesses surveyed could not answer.

3.2.5.4 Business Owner/Operator Responses to Specific Survey Inquiries

The nine business owner/operators depicted above were asked specific questions; following is a summary of their responses.

Why do you think people chose this destination?

Three of the nine owners/operators stated that their businesses included a campground, a beach, and a RV campground, which place them in a "destination park" category for multiple types of visits and visitors. The remaining responses were divided into four categories including Aesthetics, Weather, Convenience, and Other. Some of the responses were in more than one category; thus, the numbers do not total 100 percent.

Three of nine respondents (33 percent) stated that aesthetics was the main reason for choosing this destination; two respondents (22 percent) mentioned the weather; and two stated conveniences as the main reason for choosing the Lower Reach destination. In the other category, three (33 percent) of the business respondents stated that the presence of canoe and kayak rental businesses as well as businesses that offered trips on the Lower Reach were the main destination criteria.

What do you think are the most important attributes to watercraft users when they come to the Lower Reach area?

The responses to this query from the nine business owners/operators were divided into four primary categories: Less Crowded, Wildlife, the River itself, and Other. Once again, some of the responses were in multiple categories, and therefore the total is not 100 percent. Four (44 percent) of the respondents mentioned less crowded as the most important attribute; 44 percent also stated that the Lower Reach itself was the most important attribute; and two (22 percent) mentioned wildlife as the most important. In the other category, the responses included attributes such as privacy, close to San Francisco, easy access, quiet, a great place for families, and a good place for inexperienced (watercraft) people.

What percent of your customers are day-use participants compared to overnight users?

In response to this query, five of the nine business owners/operators reported that 100 percent of their customers were day users. One respondent stated that 75 percent of the customers were day users, and another said 90 percent. One respondent replied that 100 percent of the customers were overnight users, and one did not respond to this question.

What is the main destination for watercraft users between Healdsburg and Jenner?

Of the nine business owners/operators queried, two stated that Guerneville was the main destination, two mentioned Healdsburg, and two could not answer. The remainder of the respondents (three) stated that Jenner, Monte Rio to Jenner, and east of Monte Rio were the main destinations between Healdsburg and Jenner.

3.3 SUMMARY OF SITE VISIT

Although river recreation does occur in other areas of the Russian River, such as Geyserville to Healdsburg, the study area included the Lower Reach and Estuary where many river-related businesses are found. Therefore, the site visit on June 2, 2003 focused on conditions pertaining to swimming and paddling (existing conditions) in those areas (Guerneville to Jenner). The canoe trip began at Guerneville and ended at Jenner and lasted approximately 6 hours. Researchers used a canoe with two paddlers and one note-taker. The river flow was approximately 240 cfs at put-in (11:00 a.m.) and approximately 234 cfs at take-out (6:00 p.m.) (California Data Exchange Center). The objective of the site visit was to identify boating attributes, including visitor information sources, use constraints, and safety.

One finding was that there was no signage along the Lower Reach identifying access sites (put-in and take-out), public and private facilities, boat rental locations and business information, nor suggested trips for various experience levels.

It would improve user experiences if a systematic information source for boat trip planning and use once on site were developed. Systematic information could be available in the form of maps, driving directions, driving length and estimated times, river lengths (boat trips), identified access sites (put-in and take-out), public and private facilities, boat rental locations and business information, and suggested trips for various experience levels. Standardized recreation and directional signs would also improve trip experiences. This would be useful for visitors accessing, and boats navigating, the Lower Reach of the Russian River.

For example, Vacation Beach and Steelhead Beach had no posted identification signs for boaters. Even the developed sites with significant recreation facilities were unidentified from the river. Regarding use constraints, shallow water sections of the river were encountered between Guerneville and Monte Rio. Specifically, shallow sections of the river were located near the summer crossing access, adjacent to Vacation Beach and just upriver from where Smith Creek enters the Lower Reach near Monte Rio.

There were no take-out sites within close proximity of Jenner. Thus, if a take-out site up-river from Jenner was missed, for example, at the Sonoma Coast Environmental Camp, boaters would have to take-out at the Jenner site approximately 3 miles down-river and that would involve paddling on water with little or no current. The take-out facility at Jenner was not well identified from the highway (e.g., no standardized, brown recreation-site informational sign).

Regarding safety, trees and brush on the shore had protruded into the path of the river in various places where boating occurs that could contact or entrap an approaching boater. Trees were also lying on the bottom of the river projecting out of the water. Built features that appeared to present potential problems to boaters included old posts, planks, docks, and other structures that were partially or entirely abandoned. For example, the area below Monte Rio is identified on angler's maps as "pilings." When navigating this feature, several partially submerged posts protrude above the water.

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This section lists and describes recreation opportunities that might continue and those that may develop under the Flow Proposal.

4.1 PADDLING USE

Under the current flow requirements (D1610), under *all* water conditions, an estimated average of 14,732 paddlers use the Lower Reach on an annual basis (Table 4-1). This number does not change under *dry* conditions for the D1610 flow requirements, and is based on weekday, weekend day, and holiday median-use figures given by the respondents in the private paddler sample. Additional details about assumptions (such as typical season length) used to estimate the above number are found in Attachment 6. It is assumed that paddlers who rent canoes or other watercraft from commercial establishments represent 50 percent of the above number, or 7,366 paddlers (Table 4-2). This assumption is based on information collected in the business survey from private business survey participants that rent canoes or kayaks. The 50 percent commercial canoeing-use figure represents the lowest figure (range was 50 to 75 percent) provided by the three business owner/operators that responded specifically to the question about commercial versus private use. Another assumption used in this estimate is that the Lower Reach will not be used by paddlers when the daily flow measured at Hacienda Bridge is below 140 cfs. This figure is not a rigid standard. It is based on literature on optimal flows for canoeing (Whittaker et al. 1993) interviews with regular paddlers of the Lower Reach, an interview with a business owner/operator, and an interview with a recreation boating study consultant. The 140-cfs figure should be thought of as a "worst-case" scenario. It is possible that highly experienced paddlers may continue to use the Lower Reach when daily flows fall below 140 cfs.

Under the Flow Proposal, for *all* water conditions, an estimated average of 4,697 paddlers would use the Lower Reach on an annual basis. Compared to current flow conditions, this represents a 68-percent reduction in average annual use.

Whether or not the loss of paddling on the Lower Reach would equate with a loss of recreation use in the study area is uncertain. It may be that recreational boating activity will shift seasonally in use, for example from summer to spring, rather than simply decrease. Interviews with resort owners and Chamber of Commerce staff indicate that visitors come to the study area to engage in a wide variety of activities, one of which is canoeing the Lower Reach. Additionally, other surveys of outdoor recreationists in California (DWR 2002, PG&E 2001) indicate that visitors who come to a particular recreation area often visit multiple recreation sites, and a majority engage in multiple recreation activities. As a result, it is likely that some portion of expenditures associated with visiting the Lower Reach for canoeing would still be "captured" by local businesses because canoeists participate in other activities such as dining, lodging, or wine tasting.

Table 4-1 Estimated Number of Existing Total Seasonal Paddling Use, Lower Russian River

Month	Number Weekdays	Number of Weekend Days	Number of Holidays	Total Number of Days
May	12	5	1	18
June	21	9		30
July	22	8	1	31
August	21	10		31
September	21	8	1	30
October	11	3		14
Total Days	108	43	3	154
Total Paddlers	**Paddlers per Day = 5,292** **(49 x 108 = 5,292)** [1]	**Paddlers per Day = 8,600** **(43 x 200 = 8,600)** [2]	**Paddlers per Day = 840** **(3 x 280 = 840)** [3]	**14,732 Paddlers per Season**

1 Median number of paddlers per weekday.
2 Median number of paddlers per weekend day.
3 Median number of paddlers per holiday.

Table 4-2 Estimated Changes in Number of Annual Paddlers on the Lower Reach

	Commercial Use, *All* Water Conditions	Private Use, *All* Water Conditions	Subtotals	Commercial Use, *Dry* Conditions	Private Use, *Dry* Conditions	Subtotals
			D1610 Scenario			
Local use[1]	1,473	5,893	7,366	1,473	5,893	7,366
Regional use[2]	5,893	1,473	7,366	5,893	1,473	7,366
Subtotals	**7,366**	**7,366**	**14,732**	**7,366**	**7,366**	**14,732**
			Flow Proposal			
Local use	469	1,874	2,343	192	740	932
Regional use	1,875	469	2,343	740	192	932
Subtotals	**2,344**	**2,343**	**4,697**	**932**	**932**	**1,864**

Notes:
1 Local use refers to paddlers that reside in Sonoma or Mendocino County.
2 Regional use refers to paddlers that reside outside of Sonoma or Mendocino County.

4.1.1 SWIMMING

Estimating swimming use as a result of the Flow Proposal involved three steps, summarized as follows. The first step involved using beach-use data for Healdsburg Veterans Memorial Beach (Table 4-3) to determine the average proportion of beach users that swim. This was the only available source of information that contained both beach and swimming use data. For other beach use data, swimming use was not reported. The proportion of beach users that were swimming at Veterans Beach varied from approximately 26 to 40 percent, while the ten-year average proportion was 32 percent. The second step involved examining historic beach-use data for three beaches to determine the average daily swimming use (Table 4-4). There were no data available on how swimming might vary by weekday, weekend day, or holiday. This 10-year average proportion was used to estimate the proportion of beach users that would swim under the Flow Proposal. No changes were made in this proportion. Step three involved determining the total average seasonal swimming use under D1610 requirements (Table 4-5) for "*dry*" and "*all* water" conditions. This step required that an assumption be made regarding the total average swimming season (100 days). Based on a review of county health standards, it is unlikely that any of the beaches in the study area would be closed for reasons related to poor water quality. As a result, the number of swimmers that would occur under the Flow Proposal is estimated at 37,100 swimmers (Table 4-5). This does not represent a change from the level of swimming use under D1610 requirements.

Table 4-3 Annual Statistics at Healdsburg Veterans Memorial Beach, 1992 to 2002

	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
2 pm Water Count	8,923	7,086	7,720	4,112	4,890	4,022	5,018	4,781	4,388	Beach Closed	3,218
2 pm Shore Count	22,262	17,833	17,935	11,614	10,918	8,488	9,317	7,225	6,736	Beach Closed	5,471
2 pm Totals	31,185	21,919	25,655	15,726	19,060	12,510	14,335	12,006	11,074	Beach Closed	8,689
% Swimming	28.6	32.3	30	26.1	25.7	32.1	35	40	39.6	N/A	37

Source: Sonoma County Regional Parks (2003). Personal communication with Bert Whitaker.

Table 4-4 Average Daily Swimmers for Beaches along the Lower Russian River

Beach	Total Historic Use[1]	Average Daily Beach User[2]	Average Daily Swimmers
Steelhead	366,000	610	226
Forestville Access	107,200	134	50
Wohler Bridge	206,400	258	95

[1] Total swimmer figures per season for each beach are based on data obtained via manual counts for 6 years for Steelhead Beach, and for 8 years for Forestville and Wohler Bridge beaches.
[2] Averages were computed by dividing total seasonal use by a season of 100 days.

Table 4-5 Estimated Average Number of Swimmers per Month for Beaches on the Lower Russian River under Existing Conditions and Flow Proposal Conditions

May		June		July		August		September		Totals	
All Water Conditions	*Dry* Conditions	*All* Water Conditions	*Dry* Conditions	*All* Water Conditions	*Dry* Conditions	*All* Water Conditions	*Dry* Conditions	*All* Water Conditions	*Dry* Conditions	*All* Water Conditions	*Dry* Conditions
D1610 Scenario											
0	0	7,047	7,047	11,498	11,498	11,498	11,498	7,047	7,047	37,100	37,100
Flow Proposal											
0	0	7,047	7,047	11,498	11,498	11,498	11,498	7,047	7,047	33,380	37,100

4.1.2 Increased Shoreline Use

Three other activities for which recreation participation may increase in the Lower Reach of the Russian River include:

- Beach use.
- Improved flyfishing opportunities.
- Improved opportunities to observe wildlife.

4.1.2.1 Increased Beach Use

Use of beach areas may increase. The 1997 California survey of recreation participation (California Department of Parks and Recreation 1998) showed high unmet demand for this activity throughout the state. Beach use, including sunning and games, showed the tenth highest unmet demand among 43 outdoor recreation activities.

4.1.2.2 Improved Flyfishing

As D1610 flows decrease in the Lower Reach under the Flow Proposal, certain types of fishing may improve. Literature supports the idea that certain flow rates, measured in cfs, are preferred for fishing. In a recent study conducted by PG&E (2001) on fishability in the Upper North Fork of the Feather River, study findings may provide insight to issues anglers and resource managers would face regarding the Lower Reach under the Flow Proposal. In the PG&E study, anglers were invited to provide information about the relationship between flows and fishability.

There appear to be significant preference differences between fly angling and spin/bait anglers. Study discussions suggested that fly anglers require lower flows because they provide better wading access to the river as well as slower velocities in rapids. Spin/bait anglers do less wading (as a general rule, they do not need as much clearance from riparian vegetation to cast). As flows in the Lower Reach decrease, the river may become better suited for fly anglers rather than spin/bait anglers as wading access increases and velocities decrease. This may improve opportunities for fly anglers interested in pursuing warmwater fish species such as smallmouth bass. However, it is likely that pools for warmwater fish habitat would be sporadically distributed. This effect on fishing use is unknown because numerous variables affect angling use.

4.2 SUMMARY

Under the current flow requirements (D1610), under *all* water conditions, an estimated 14,732 paddlers use the Lower Reach on an annual basis. Under the Flow Proposal, for *all* water conditions, an estimated 4,697 paddlers would use the Lower Reach on an annual basis. Compared to current flow conditions, this represents a 68-percent reduction in use. Whether or not the loss of paddling on the Lower Reach would equate with a loss of recreation use in the study area is uncertain.

Sport fishing is another river-related recreational activity popular throughout most of the year. Summer fishing on the Lower Reach occurs for smallmouth bass and catfish including small numbers of shad and striped bass. Fishing for steelhead accounts for the majority of the fish sought. The peak fishing season is from October through March, although fishing trips may occur throughout the year.

Regarding swimming and beach use, with the exception of Healdsburg, all beaches show steady increases in annual attendance. Steelhead Beach shows the largest percentage increase in use and the highest total number of visitors reported during the 2001-2002 season.

It may be that recreational boating activity would shift seasonally in use; for example from summer to spring, rather than simply decrease. Boating opportunities would probably not disappear on the Lower Reach. It is likely that they would decrease, but watercraft use should continue regularly through June 30. Spring and fall boating may become more popular as late or early rainfall provides flows greater than those found during summer under the Flow Proposal. Fall use of the Lower Reach was mentioned by several survey respondents and professional fishing guides as a good opportunity to view wildlife on the Lower Reach, an activity that many recreationists seek. Several other recreation studies in the region demonstrate that recreationists participate in several activities at a site (PG&E 2001, DWR 2002). While summer canoeing may decrease in the Lower Reach, recreation users may shift their activities to other secondary pursuits such as sunning, wading, hiking, or wildlife watching.

Interviews with resort owners and Chamber of Commerce staff indicate that visitors come to the study area to engage in a wide variety of activities, one of which is canoeing on the Lower Reach. Additionally, other surveys of outdoor recreationists in California (PG&E 2001) indicate that visitors who come to a particular recreation area often visit multiple recreation sites, and that a majority engage in multiple recreation activities. As a result, it seems possible that some portion of expenditures associated with visiting the Lower Reach for the purpose of canoeing would still be “captured” by local businesses because canoeists participate in other activities such as dining, lodging, or wine tasting (NEA 2003).

If the proposed flow reduction occurs, it is likely that recreation opportunities will shift from watercraft-dominant to shoreline-based. Changes to current recreation supply and demand of opportunities may occur in the following areas:

- Increased shoreline use.
- Improved flyfishing opportunities.

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ATTACHMENT 1

AGENCY SURVEY FORM

Survey No. _______Date ____________________ Time __________ Researcher _________________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

What is your full name? ____

What agency do you work for and where are you based? ____

What is the agency's full location address?

____

____

Where and how does the ___________ agency interact with watercraft, swimmers, and tubers on the Russian River between Healdsburg and Jenner?

____

____

____

What percent of river boaters are day users versus overnight users? Day ____% Overnight ____%

Aside from boating, are there differences in day use vs. overnight user activities? Yes ____ ➠ If yes, what

____

Regarding canoeing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

Do you have a sense of total use, in the measure of individual visits? No ____ Yes ____ ➠ If yes, # ___________________

How did you arrive at this estimate? ____

Approximately how much use by canoes and other watercraft is there on the section you know best:
[a reasonable estimate is appropriate]

Specify reach from _____________ to _____________ (individual visits ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:
[*a reasonable estimate is appropriate*]

Specify reach from _____________ to _____________ (individual visits ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you know of any records of watercraft or swimming use? Yes ____ No ____

If yes, may we look at them? Yes ____

How was use calculated? ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

If yes, do the records contain zip code information? Yes ____ No ____

If no records can be obtained, can you estimate the places of origin of visitors No ____ Yes ____

If yes, areas include

____

____

Do you know of any use estimates for the entire stretch between Healdsburg and Jenner? Yes ____ No ____

If yes, can we obtain it? Yes ____ No ____ ➠ [If yes, arrange]

What would you say is the main destination for watercraft users on the Russian River between Healdsburg and Jenner? ____________________________ *Why?*

____

Why do you think people choose this destination? ____________________________

What do you think are the most important attributes to watercraft users when they come to the Russian River area?

____

____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ______________

If yes, during what year(s) was boating/swimming/tubing use unusually low? ____________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would watercraft users still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➠ If yes, where?______________________________

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times ______________

❒ Other activities or services? What would they be? ______________________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

____

One question related to fishing on the Russian River, what is the demand for salmonid and bass fishing? (i.e. high, low) Salmonid: high ❒ low ❒ Bass: high ❒ low ❒

Is there anyone you think we should contact and speak with about watercraft use and swimming on the Russian River? Yes ____ No ____ ➠ If yes, who

____

____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 2

REGULAR RECREATION USER SURVEY FORM

Survey No. ________Date ____________________ Time __________ Researcher ________________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

Confirm contact's full name ____

Do you have knowledge about watercraft use or swimming at the Russian River between Healdsburg and Jenner?

Yes ____ *No* ____

[*If no, skip to another survey or thank them and terminate if they are completely unknowledgeable*]

What's your zip code so we can tell where you're from? ____________________ [*we won't use it for other reasons*]

How long have you been involved with watercraft use or swimming in this area? _________ (years)

Please estimate how many times you have canoed or used watercraft on the Russian River ____ (times).

Do you use shuttle services? Yes ____ No ____ ➠ If yes, paid or friends __________ ➠ If paid, $ ____ average.

Regarding canoeing on the Russian River from <u>Healdsburg to Jenner</u>, let's talk about use levels.

What part(s) of the Russian River between Healdsburg and Jenner are you most knowledgeable about?

____

Approximately how much use by canoes and other watercraft is there on the section you know best:
*[*a reasonable estimate is appropriate*]*

Specify reach from ____________ to ____________ (individual <u>visits</u> ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from <u>Healdsburg to Jenner</u>, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:
[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual <u>visits</u> ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you know of any records of use? Yes ____ No ____

If yes, may we look at them? Yes ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

What would you say is <u>your</u> main destination for recreation on the Russian River between Healdsburg and Jenner?

____

Why? ____

Why do <u>you</u> like this area(s)? ____

What are the most important attributes that motivate <u>you</u> to come to the Russian River rather than some other place?

____

____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ______________________

If yes, during what year(s) was boating/swimming/tubing use unusually low? _____________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would you still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➠ If yes, where?____

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times ________________

❒ Other activities or services? What would they be? _________________________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

____

Is there anyone you think we should contact and speak with about watercraft use and swimming on the Russian River?

Yes ____ No ____

If yes, who

____

____

____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 3

BUSINESS SURVEY FORM

Business Owner/Operator Survey **Russian River BA: Recreation**

Survey No. _________ Date ____________________ Time __________ Researcher ______________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

Confirm contact's full name ____

Do you have a business in the Russian River area that deals with watercraft, beach use, or swimming? Yes ____ No ____

[*If no, skip to another survey or thank them and terminate if they are completely unknowledgeable*]

If yes, name business and full location address

____

____

How long have you been in business _________ years?

What do you do at ______ business? ____

Regarding canoeing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

What part (s) of the Russian River between Healdsburg and Jenner are you most knowledgeable about?

____

What percent of your customers are day users versus overnight users? Day ____% Overnight ____%

ATTACHMENT 4

SELF-ADMINISTER E-MAIL SURVEY
FOR CHAMBER OF COMMERCE MEMBERS

Please estimate the percent of your customers who use shuttle services ____% ➠ of those, what percent are paid? ____%

What percent of river use do you estimate is commercial (guided trips)? ____%

Approximately how much use by canoes and other watercraft is there on the section you know best:

*[*a reasonable estimate is appropriate*]*

Specify reach from ____________ to ____________ (individual visits ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual visits ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you have actual records of use? Yes ____ No ____

[*NOTE: we're not interested in your personal finances, we just want to know accurately how much river boat use there is in the lower reach of the Russian River*]

If yes, may we look at them? Yes ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

[If no records of use exist ➘]

Can you estimate where the majority of your business' users originate?

____

____

What would you say is the main destination for watercraft users on the Russian River between Healdsburg and Jenner?

____

Why? ____

Why do you think people choose your business? ____

What do you think are the most important attributes for customers in the Russian River area?____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ___________________

If yes, during what year(s) was boating/swimming/tubing use unusually low? ______________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would watercraft users still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➠ If yes, where?____

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times _____________

❒ Other activities or services? What would they be? ___________________________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

Is there anyone you think we should contact and speak with about boating and swimming on the Russian River?

Yes ____ No ____

If yes, who ____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 5

LIST OF CONTACTS

Recreation User Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
✓	4-30 6-17 7-3	Margaret Nelson Sandy Brown Steve Fogle	The Russian River Chamber of Commerce	Canoeing	707-869-9000	web
✓	4-24	George Zastrow	Sequoia Paddling Club (Pres.)	Canoeing	707-869-0700	Web (George knows a lot of contacts)
✓	4-25	Tom Meldau	Sequoia Paddling Club (Vice. Pres.)	Canoeing	707-887-7416	web
✓	4-28	Suki Gitchell	Sequoia Paddling Club (Conservation Chair)	Canoeing	c) 707-477-2299 h)707-865-2248	web
✓	4-28	Michelle Luna	Stewards of Slavianca	Canoeing	707-869-9177	http://www.sonomapicnic.com/05/slaviank.htm
✓		Tom Roth, Peter Vilms✓, Joan Vilms✓	Friends of the Russian River	Canoeing and Swimming	707-865-1305	http://www.envirocentersoco.org/forr/
✓	4-30	Don McEnhill	River Keeper	Canoeing and Swimming	707-433-1958	gbtc@aol.com
✓	4-30	Ann Dwyer	Kiwi Kayak Club	Boating	707-433-6707	
✓	5-2	Gina Cassini	Cassini's Campground	Camping	800-451-8400	
✓	4-30	Mike Swaney	Trout Unlimited		707-829-3580	
✓	5-27	Bryan Hines	Friends of RR	N. Coast Solar Resources	707-575-3999	
✓	5-1	Laura Wilson	Johnson's Beach Resort	Swimming	707-869-2022	http://www.johnsonsbeach.com/ho

						me.htm
Recreation User Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
✓	5-13	Niki Rubin	West Coast Kayak		707-869-9716, 707-869-9717	private river tours
	5-27, left msgs	Bob/ Linda Burke	Burke's Canoe Trips		707-887-1222, fax: 707-887-2000	private river tours
	?	Ann Dwyer	California Kayak Academy		707-838-0141	
✓	4-25	John Condon	California Rivers Wine tours & Kayaks		707.579.2209	
✓	4-28	Patrick	Gold Coast Kayaks/ The Russian River Outfitters		707-865-1441	web
	Left msg	Tom Meldau	Mr. Canoe's Paddlesports		707.887.7416	
✓	5-23	Phil Wright	Trowbridge Canoe Trips	Phil Wright 707-838-3200 Chris Wright 707-473-4374	800-640-1386	Said to be worthy of a lot of information about RR boating
✓	6-19	Steve Jackson/Erik Laughmiller	King's Fishing & Kayak		707-869-2156	
✓	5-12	Larry Laba	SOAR Manufacturing		707-433-5599	web
✓	5-27	Mirabel Park Campground	Campground, rent canoes/kayaks		707-887-2383	
		Nate Rangal	CA Outdoors	Coloma, CA- not relevant	530-626-7385	Ref: John Gangemi- American Whitewater

Recreation User Contacts

Contacted	Date	Person’s name	Agency or Group	Related to…	Phone	Further Info
✓	7-2	Alby Kass Mailed business survey				
✓	6-4	Rick	The Willows Resort		707-869-2824	
✓	6-23	Karen	Fifes		707.869.0656	
✓	6-23	Meena	Northwood Lodge		707-865-1655	
✓		Referred to their website when called	Sonoma County Tourism Program		800-5-sonoma, 707-565-5383	http://www.sonoma-county.org/edb/Reports.htm : Tourism info.
✓	5-30	Bert Whitaker	Sonoma County Aquatics		707-565-2824	
Left msgs, recent 7/2		Allan Darrimon	Sonoma County Regional Parks Dept		707-565-2041	
			Forestville River Access			http://www.sonoma-county.org/parks/pk_forst.htm
	Left msg	Robert Baba	Forestville Chamber of Commerce		707-887-1111	
✓	4-28	Richard Edwards	Monte Rio Parks and Recreation District		707.865.2487	
	Left msgs recent 7/2		Monte Rio Chamber of Commerce		707-865-1533	
X	X		Armstrong State Park and Recreation Area		707-869-2015 or 865-2391	
✓	6/17	Carla	Healdsburg Chamber of Commerce		707-433-6935	

Recreation User Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
X	X		Sonoma County Health Department-- Community Health Services Communicable Disease Control	Swimming	707-565-4567	http://www.sonoma-county.org/health/ph/contact.htm

X indicates : Attempted contacting and No relevant feedback (river recreational use) obtained.

Site or doc. name	Agency or Group	Related to…	Phone	Further Info
Rein's Sandy Beach	Private Called. Call again 5-29 (new business-no data)	Beach and long-term RV rental sites.	707-865-2102	Directions: Take Route 116, towards the ocean (west). Go several miles on 116 and take a left at the sign for Rein's Sandy Beach, take a right at the end of the road. Cost: $2.00 per person.
Vacation Beach		Residential area		
Steelhead Beach	Sonoma County	Day use area	(707) 565-2041	May have use #s based on fee collections
Beach, Robert, F.	Document	Min. in-stream flow study	Possibly, contact Sonoma County for doc.	The Russian River: An assessment of its condition and government oversight. August 1996. Beach, Robert, F.

ATTACHMENT 6

ASSUMPTIONS FOR RECREATION:
RIVER RECREATION USE ESTIMATES

Assumptions for Russian River recreation use estimates

1. The typical canoeing/boating season begins in mid-May and ends in mid October, for a total season length of about 5 months (154 days). This assumption is based on conversations with local canoe rental establishments and recognition that decreasing daylight and temperature will mark the end of the recreation use period in the Fall.

2. The typical swimming season is 100 days. The season begins in late June and ends by September 30.

3. The lower reach of the Russian River is not boatable when the daily flow is less than 140 cfs, as measured by the gaging station near Hacienda Bridge (Whittaker et al., 1993).

4. There will be 5 days per month from July 1 through August 31 when swimming conditions at beaches along the lower reach of the Russian River are unattractive to the extent that recreationists will not swim on those days.

5. The following tables estimates the number of boatable and swimmable days under "all" water supply conditions and dry water supply conditions. Recreational canoeing estimates provided by the members of the business community represent a subset of total canoeing use. As a result, estimates of canoeing use provided by recreational users will be used as a basis for calculating total seasonal canoeing use. Median values for weekends, weekdays, and holidays will be used to estimate the amount of canoeing/other watercraft use on the days when the lower reach is boatable.

ALL	**May**		**June**		**July**		**August**		**September**		**October**	
Activity	D1610 All	ENFP NM – All water conds.	D1610 All	ENFP NM- All water conds.	D1610 All	ENFP NM- All water conds.	D1610 All	ENFP NM All Water conds	D1610 All	ENFP NM All water conds	D1610 All	ENFP NM All Water conds
Paddling	15	15	25	14	31	8	31	0	30	0	10	0
Swim	0	0	19	19	31	0	31	0	19	0	0	0
DRY	**May**		**June**		**July**		**August**		**September**		**October**	
Activity	D1610 Dry	ENFP NM Dry water conds.	D1610 Dry	ENFP NM Dry water conds.	D1610 Dry	ENFP NM Dry water conds.	D1610 Dry	ENFP NM Dry	D1610 Dry	ENFP NM Dry	D1610 Dry	ENFP NM Dry
Paddling	14	13	25	8	31	0	31	0	0	0	3	0
Swim	0	0	19	9	31	0	31	0	0	0	0	0

6. Recreational swimming represents 37% of total beach use (NOTE: this is based on 10 years of observational data collected at Veteran's Beach near Healdsburg).

7. Each canoe/watercraft has an average party size of two persons.

8. The percentage of canoeing/watercraft use that is commercial is 50%. This represents the lowest estimate provided by the three businesses that answered this question.

9. The percentage of commercial canoe/watercraft users from outside Sonoma and Mendocino counties is 80%. This percentage is based on survey results from five businesses that answered this question, indicating the majority were from the San Francisco Bay area. The percentage of private canoe/watercraft users from outside Sonoma and Mendocino counties is 20%. This is based on survey results from private boaters.

D1610 Scenario-Canoeing Estimate

	Comm'l use D1610 All water	Private use D1610 All water	Comm'l use D1610 Dry	Private use D1610 Dry
Local (Mendocino and Sonoma counties)	1473	5893	1473	5893
Regional	5893	1473	5893	1473
Subtotals	7366	7366	7366	7366

ENFPnm Scenario-Canoeing Estimate

	Comm'l use ENFPnm All Water	Private use D1610 All Water	Comm'l use ENFPnm Dry	Private Use Dry
Local (Mendocino and Sonoma counties)	469	1875	192	740
Regional	1875	469	740	192
Subtotals	2344	2344	932	932

ATTACHMENT 7

SURVEY RESULTS

INTRODUCTION

The following pages present the results of the three surveys regarding recreation use on the Lower Reach. The results are presented in a matrix format, and include responses from nine business owners/operators, three agency staff, and ten recreational paddlers (see page 2-2 of this appendix for more detailed information).

Responses from business owners/operators are presented on pages 1 through 4 of this attachment. The respondents (B1 through B9) are listed vertically in the first column on page 1, and the answers provided by each of those respondents are presented horizontally across four pages. Likewise, responses from agency staff (respondents A1 through A3) are presented on pages 5 through 8, and responses from recreational paddlers (respondents R1 through R10) are presented on pages 9 through 12.

The Survey results are in the process of being formatted at this time.

ATTACHMENT 1

AGENCY SURVEY FORM

Survey No. _______Date ____________________ Time __________ Researcher ________________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

Confirm contact's full name ____

Do you have knowledge about watercraft use or swimming at the Russian River between Healdsburg and Jenner?

Yes ____ No ____

[*If no, skip to another survey or thank them and terminate if they are completely unknowledgeable*]

What's your zip code so we can tell where you're from? ____________________ [*we won't use it for other reasons*]

How long have you been involved with watercraft use or swimming in this area? _________ (years)

Please estimate how many times you have canoed or used watercraft on the Russian River ____ (times).

Do you use shuttle services? Yes ____ No ____ ➠ If yes, paid or friends __________ ➠ If paid, $ ____ average.

Regarding canoeing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

What part(s) of the Russian River between Healdsburg and Jenner are you most knowledgeable about?

____

Approximately how much use by canoes and other watercraft is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual visits ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual visits ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you know of any records of use? Yes ____ No ____

If yes, may we look at them? Yes ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

What would you say is <u>your</u> main destination for recreation on the Russian River between Healdsburg and Jenner?

____

Why? ____

Why do <u>you</u> like this area(s)? ____

What are the most important attributes that motivate <u>you</u> to come to the Russian River rather than some other place?

____

____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ____________________

If yes, during what year(s) was boating/swimming/tubing use unusually low? ____________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would you still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➠ If yes, where?____

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times ______________

❒ Other activities or services? What would they be? ____________________________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

Is there anyone you think we should contact and speak with about watercraft use and swimming on the Russian River?

Yes ____ No ____

If yes, who

____

____

____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 2

REGULAR RECREATION USER SURVEY FORM

Survey No. _________ Date ____________________ Time __________ Researcher _____________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

Confirm contact's full name ____

Do you have a business in the Russian River area that deals with watercraft, beach use, or swimming? Yes ____ No ____

[*If no, skip to another survey or thank them and terminate if they are completely unknowledgeable*]

If yes, name business and full location address

____

____

How long have you been in business _________ years?

What do you do at ______ business? ____

Regarding canoeing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

What part (s) of the Russian River between Healdsburg and Jenner are you most knowledgeable about?

____

What percent of your customers are day users versus overnight users? Day ____% Overnight ____%

Please estimate the percent of your customers who use shuttle services ____% ➠ of those, what percent are paid? ____%

What percent of river use do you estimate is commercial (guided trips)? ____%

Approximately how much use by canoes and other watercraft is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual visits ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ____________ to ____________ (individual visits ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you have actual records of use? Yes ____ No ____

[*NOTE: we're not interested in your personal finances, we just want to know accurately how much river boat use there is in the lower reach of the Russian River*]

If yes, may we look at them? Yes ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

[If no records of use exist ➘]

Can you estimate where the majority of your business' users originate?

____

____

What would you say is the main destination for watercraft users on the Russian River between Healdsburg and Jenner?

____

Why? ____

Why do you think people choose your business? _______________________________________

What do you think are the most important attributes for customers in the Russian River area?____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ________________

If yes, during what year(s) was boating/swimming/tubing use unusually low? ___________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would watercraft users still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➟ If yes, where?____

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➟ If yes, what times ____________

❒ Other activities or services? What would they be? ______________________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

Is there anyone you think we should contact and speak with about boating and swimming on the Russian River?

Yes ____ No ____

If yes, who ____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 3

BUSINESS SURVEY FORM

Survey No. _______Date ____________________ Time __________ Researcher ________________________________

Hello, my name is _____ and I'm working on a recreation survey for a study being conducted by the Sonoma County Water Agency. I'd like to take a few minutes to ask you a number of questions about canoeing and swimming on the Russian River. I'm particularly interested in the stretch of the Russian River between Healdsburg and the ocean near Jenner. The information you provide will be used by the Sonoma County Water Agency to understand the relationship between flows and recreation use patterns in the Russian River area. These questions will only take a few minutes, would you be willing to help?

[*If yes, proceed. If no, thank them anyway and say goodbye*]

What is your full name? ____

What agency do you work for and where are you based? ____

What is the agency's full location address?

____

____

Where and how does the ___________ agency interact with watercraft, swimmers, and tubers on the Russian River between Healdsburg and Jenner?

____

____

____

What percent of river boaters are day users versus overnight users? Day ____% Overnight ____%

Aside from boating, are there differences in day use vs. overnight user activities? Yes ____ ➠ If yes, what

____

Regarding canoeing on the Russian River from <u>Healdsburg to Jenner</u>, let's talk about use levels.

Do you have a sense of total use, in the measure of individual visits? No ____ Yes ____ ➠ If yes, # __________________

How did you arrive at this estimate? ____

Approximately how much use by canoes and other watercraft is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ___________ to ___________ (individual <u>visits</u> ➘)	canoes	other watercraft
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from <u>Healdsburg to Jenner</u>, let's talk about use levels.

Approximately how much use by swimmers and tubers is there on the section you know best:

[*a reasonable estimate is appropriate*]

Specify reach from ___________ to ___________ (individual <u>visits</u> ➘)	swimmers	tubers
Summer weekday?		
Summer weekend day?		
Summer holiday weekend day?		

Do you know of any records of watercraft or swimming use? Yes ____ No ____

If yes, may we look at them? Yes ____

How was use calculated? ____

[*Arrange to obtain then ASAP email preferred; fax and snail mail okay; summary okay also*]

If yes, do the records contain zip code information? Yes ____ No ____

If no records can be obtained, can you estimate the places of origin of visitors No ____ Yes ____

If yes, areas include

____

____

Do you know of any use estimates for the entire stretch between Healdsburg and Jenner? Yes ____ No ____

If yes, can we obtain it? Yes ____ No ____ ➠ [If yes, arrange]

What would you say is the main destination for watercraft users on the Russian River between Healdsburg and Jenner? ______________________ Why? ______________________

Why do you think people choose this destination? ______________________________

What do you think are the most important attributes to watercraft users when they come to the Russian River area?

____

____

Can you detect a difference in use levels during drought years? Yes ____ No ____

Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ______________

If yes, during what year(s) was boating/swimming/tubing use unusually low? ________ years

About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

Would watercraft users still come to the river during low flow conditions? Yes ____ No ____

Would any of the following encourage your use during low flow conditions?

❒ Portage services? ➠ If yes, where?______________________________

❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times __________

❒ Other activities or services? What would they be? ______________________

Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

One question related to fishing on the Russian River, what is the demand for salmonid and bass fishing? (i.e. high, low)
Salmonid: high ❒ low ❒ Bass: high ❒ low ❒

Is there anyone you think we should contact and speak with about watercraft use and swimming on the Russian River?
Yes ____ No ____ ➠ If yes, who

____

____

That's it for my questions, do you have any other questions or comments?

____

____

Thanks for your time and knowledge. Goodbye.

ATTACHMENT 4

BUSINESS OWNER/OPERATOR SURVEY FORM

1. Your full name ____

2. Do you have a business in the Russian River area that deals with watercraft, beach use, or swimming? Yes ____ No __

   3. If yes, name business and full location address

____

____

4. How long have you been in business _________ years?

5. What do you do at your business? ____

Regarding canoeing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

6. What part (s) of the Russian River between Healdsburg and Jenner are you most knowledgeable about?

____

7. What percent of your customers are day users versus overnight users? Day ____% Overnight ____%

8. Please estimate the percent of your customers who use shuttle services ___% ➟ of those, what percent are paid? ___%

9. What percent of river use do you estimate is commercial (guided trips)? ___%

10. Approximately how much use by canoes and other watercraft is there on the section you know best:

[*a reasonable estimate is appropriate*]

a. Specify reach from ____________ to ____________ (individual visits ➘)	canoes	other watercraft
b. Summer weekday?		
c. Summer weekend day?		
d. Summer holiday weekend day?		

Regarding swimming and tubing on the Russian River from Healdsburg to Jenner, let's talk about use levels.

11. Approximately how much use by swimmers and tubers is there on the section you know best:

[*a reasonable estimate is appropriate*]

a. Specify reach from ____________ to ____________ (individual visits ➘)	swimmers	tubers
b. Summer weekday?		
c. Summer weekend day?		
d. Summer holiday weekend day?		

12. Do you have actual records of use? Yes ____ No ____

[*NOTE: we're not interested in your personal finances, we just want to know accurately how much river boat use there is in the lower reach of the Russian River*]

13. If yes, may we look at them? Yes ____ No ____

   [If no records of use exist ➘]

14. Can you estimate where the majority of your business' users originate?

____

____

15. What would you say is the main destination for watercraft users on the Russian River between Healdsburg and Jenner? ____

16. Why? ____

17. Why do you think people choose your business?

____

18. What do you think are the most important attributes for customers in the Russian River area?

____

19. Can you detect a difference in use levels during drought years? Yes ____ No ____

20. Is this based on a feeling, or something you can pinpoint? Feeling ____ Pinpoint ________________________

21. If yes, during what year(s) was boating/swimming/tubing use unusually low? ________________ years

22. About how much of a percentage decrease in use was there? ____ % decrease compared to non-drought years.

23. Would watercraft users still come to the river during low flow conditions? Yes ____ No ____

24. Would any of the following encourage your use during low flow conditions?

a. ❒ Portage services? ➠ If yes, where?____

b. ❒ The use of inflatable kayaks, or some other vessel that can better tolerate low flow conditions?

c. ❒ Special timing of releases from Lake Sonoma/ Lake Mendocino? ➠ If yes, what times __________________

d. ❒ Other activities or services? What would they be? ________________________________

25. Would you have any other concerns related to continuing your recreation use during periods of lower flows?

____

____

26. Is there anyone you think we should contact and speak with about boating and swimming on the Russian River?

Yes ____ No ____

27. If yes, who ____

That's it for our questions, do you have any other questions or comments?

____

____

____

____

____

____

Thanks for your time and knowledge.

Please return the completed survey within two weeks in order for your information to be considered as part of this study.

ATTACHMENT 5

LIST OF CONTACTS

Recreation User Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
✓	4-30 6-17 7-3	Margaret Nelson Sandy Brown Steve Fogle	The Russian River Chamber of Commerce	Canoeing	707-869-9000	web
✓	4-24	George Zastrow	Sequoia Paddling Club (Pres.)	Canoeing	707-869-0700	Web (George knows a lot of contacts)
✓	4-25	Tom Meldau	Sequoia Paddling Club (Vice. Pres.)	Canoeing	707-887-7416	web
✓	4-28	Suki Gitchell	Sequoia Paddling Club (Conservation Chair)	Canoeing	c) 707-477-2299 h)707-865-2248	web
✓	4-28	Michelle Luna	Stewards of Slavianca	Canoeing	707-869-9177	http://www.sonomapicnic.com/05/slaviank.htm
✓		Tom Roth, Peter Vilms✓, Joan Vilms✓	Friends of the Russian River	Canoeing and Swimming	707-865-1305	http://www.envirocentersoco.org/forr/
✓	4-30	Don McEnhill	River Keeper	Canoeing and Swimming	707-433-1958	gbtc@aol.com
✓	4-30	Ann Dwyer	Kiwi Kayak Club	Boating	707-433-6707	
✓	5-2	Gina Cassini	Cassini's Campground	Camping	800-451-8400	
✓	4-30	Mike Swaney	Trout Unlimited		707-829-3580	
✓	5-27	Bryan Hines	Friends of RR	N. Coast Solar Resources	707-575-3999	

Recreation-related Business Owner/Operator Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
✓	5-1	Laura Wilson	Johnson's Beach Resort	Swimming	707-869-2022	http://www.johnsonsbeach.com/home.htm
✓	5-13	Niki Rubin	West Coast Kayak		707-869-9716, 707-869-9717	private river tours
	5-27, left msgs	Bob/ Linda Burke	Burke's Canoe Trips		707-887-1222, fax: 707-887-2000	private river tours
	?	Ann Dwyer	California Kayak Academy		707-838-0141	
✓	4-25	John Condon	California Rivers Wine tours & Kayaks		707.579.2209	
✓	4-28	Patrick	Gold Coast Kayaks/ The Russian River Outfitters		707-865-1441	web
	Left msg	Tom Meldau	Mr. Canoe's Paddlesports		707.887.7416	
✓	5-23	Phil Wright	Trowbridge Canoe Trips	Phil Wright 707-838-3200 Chris Wright 707-473-4374	800-640-1386	Said to be worthy of a lot of information about RR boating
✓	6-19	Steve Jackson/Erik Laughmiller	King's Fishing & Kayak		707-869-2156	
✓	5-12	Larry Laba	SOAR Manufacturing		707-433-5599	web
✓	5-27	Mirabel Park Campground	Campground, rent canoes/kayaks		707-887-2383	
		Nate Rangal	CA Outdoors	Coloma, CA- not relevant	530-626-7385	Ref: John Gangemi- American Whitewater
✓	7-2	Alby Kass Mailed business survey				

✓	6-4	Rick	The Willows Resort		707-869-2824	
✓	6-23	Karen	Fifes		707.869.0656	
✓	6-23	Meena	Northwood Lodge		707-865-1655	

Agency Contacts

Contacted	Date	Person's name	Agency or Group	Related to…	Phone	Further Info
✓		Referred to their website when called	Sonoma County Tourism Program		800-5-sonoma, 707-565-5383	http://www.sonoma-county.org/edb/Reports.htm : Tourism info.
✓	5-30	Bert Whitaker	Sonoma County Aquatics		707-565-2824	
Left msgs, recent 7/2		Allan Darrimon	Sonoma County Regional Parks Dept		707-565-2041	
			Forestville River Access			http://www.sonoma-county.org/parks/pk_forst.htm
	Left msg	Robert Baba	Forestville Chamber of Commerce		707-887-1111	
✓	4-28	Richard Edwards	Monte Rio Parks and Recreation District		707.865.2487	
	Left msgs recent 7/2		Monte Rio Chamber of Commerce		707-865-1533	
X	X		Armstrong State Park and Recreation Area		707-869-2015 or 865-2391	
✓	6/17	Carla	Healdsburg Chamber of Commerce		707-433-6935	

Agency Contacts						
Contacted	**Date**	**Person's name**	**Agency or Group**	**Related to…**	**Phone**	**Further Info**
X	X		Sonoma County Health Department-- Community Health Services Communicable Disease Control	Swimming	707-565-4567	http://www.sonoma-county.org/health/ph/contact.htm

X indicates : Attempted contacting and No relevant feedback (river recreational use) obtained.

Site or doc. name	Agency or Group	Related to…	Phone	Further Info
Rein’s Sandy Beach	Private Called. Call again 5-29 (new business-no data)	Beach and long-term RV rental sites.	707-865-2102	Directions: Take Route 116, towards the ocean (west). Go several miles on 116 and take a left at the sign for Rein's Sandy Beach, take a right at the end of the road. Cost: $2.00 per person.
Vacation Beach		Residential area		
Steelhead Beach	Sonoma County	Day use area	(707) 565-2041	May have use #s based on fee collections
Beach, Robert, F.	Document	Min. in-stream flow study	Possibly contact Sonoma County for doc.	The Russian River: An assessment of its condition and government oversight. August 1996. Beach, Robert, F.

ATTACHMENT 6

ASSUMPTIONS FOR RECREATION:
RIVER RECREATION USE ESTIMATES

Assumptions for Russian River recreation use estimates

1. The typical canoeing/boating season begins in mid-May and ends in mid October, for a total season length of about 5 months (154 days). This assumption is based on conversations with local canoe rental establishments and recognition that decreasing daylight and temperature will mark the end of the recreation use period in the Fall.
2. The typical swimming season is 100 days. The season begins in late June and ends by September 30.
3. The lower reach of the Russian River is not boatable when the daily flow is less than 140 cfs, as measured by the gaging station near Hacienda Bridge (Whittaker et al., 1993).
4. There will be 5 days per month from July 1 through August 31 when swimming conditions at beaches along the lower reach of the Russian River are unattractive to the extent that recreationists will not swim on those days.
5. The following tables estimates the number of boatable and swimmable days under "all" water supply conditions and dry water supply conditions. Recreational canoeing estimates provided by the members of the business community represent a subset of total canoeing use. As a result estimates of canoeing use provided by recreational users will be used as a basis for calculating total seasonal canoeing use. Median values for weekends, weekdays, and holidays will be used to estimate the amount of canoeing/other watercraft use on the days when the lower reach is boatable.

	May		June		July		August		September		October	
Activity	D1610 All	ENFPNM -All water conds.	D1610 All	ENFP NM- All water conds.	D1610 All	ENFP NM- All water conds.	D1610 All	ENFPNM All Water conds	D1610 All	ENFPNM All water conds	D1610 All	ENFPNM- All Water conds
Paddling	15	15	25	14	31	8	31	0	30	0	10	0
Swim	0	0	19	19	31	0	31	0	19	0	0	0

	May		June		July		August		September		October	
Activity	D1610 Dry	ENFP NM Dry water conds.	D1610 Dry	ENFPNM Dry water conds.	D1610 Dry	ENFP NM Dry water conds.	D1610 Dry	ENFPNM Dry	D1610 Dry	ENFPNM Dry	D16	ENFPNM Dry
Paddling	14	13	25	8	31	0	31	0	0	0	3	0
Swim	0	0	19	9	31	0	31	0	0	0	0	0

6. Recreational swimming represents 37% of total beach use (NOTE: this is based on 10 years of observational data collected at Veteran's Beach near Healdsburg).
7. Each canoe/watercraft has an average party size of two persons.
8. The percentage of canoeing/watercraft use that is commercial is 50%. This represents the lowest estimate provided by the three businesses that answered this question.
9. The percentage of commercial canoe/watercraft users from outside Sonoma and Mendocino counties is 80%. This percentage is based on survey results from five businesses that answered this question, indicating the majority were from the San Francisco Bay area. The percentage of private canoe/watercraft users from outside Sonoma and Mendocino counties is 20%. This is based on survey results from private boaters.

D1610 Scenario-canoeing estimate

	Comm'l use D1610 All water	Private use D1610 All water	Comm'l use D1610 Dry	Private use D1610 Dry
Local (Mendocino and Sonoma counties)	1473	5893	1473	5893
Regional	5893	1473	5893	1473
Subtotals	7366	7366	7366	7366

ENFPnm Scenario-canoeing estimate

	Comm'l use ENFPnm All Water	Private use D1610 All Water	Comm'l use ENFPnm Dry	Private Use Dry
Local (Mendocino and Sonoma counties)	469	1875	192	740
Regional	1875	469	740	192
Subtotals	2344	2344	932	932

ATTACHMENT 7

SURVEY RESULTS

The following pages present the results of the three surveys regarding recreation use on the Lower Reach. The results are presented in a matrix format, and include responses from nine business owners/operators, three agency staff, and ten recreational paddlers (see page 2-2 of this appendix for more detailed information).

Responses from business owners/operators are presented on pages 1 through 4 of this attachment. The respondents (B1 through B9) are listed vertically in the first column on page 1, and the answers provided by each of those respondents are presented horizontally across four pages. Likewise, responses from agency staff (respondents A1 through A3) are presented on pages 5 through 8, and responses from recreational paddlers (respondents R1 through R10) are presented on pages 9 through 12.

Survey No.	Survey time	Date	Researcher initials	Respondent's name	Knowledge (yes=1; no=0)	Zipcode	No. of yrs	No. of times	Use shuttle (yes=1; no=0)
R1	10:15	24-Apr	GD	George Zastrow	1	95446	20	2080 (~2 day/wk @20 yrs.)	1
R2	11:45	25-Apr	AD	Tom Meldau	1	95448	20	1040 (avg 1day/wk @20 yrs)	1
R3	14:25	25-Apr	AD	John Condon	1	95401	25	78 (3 days/wk @ 6 months)	1
R4	10:15	28-Apr	AD	Michelle Luna	1	95430	3	10	0
R5	10:30	28-Apr	AD	Suki Gitchell	1	95450	38	1976 (1/wk @52 wks@38 yrs)	1
R6	9:30	30-Apr	AD	Ann Dwyer	1	95448	45	1500	1
R7	11:00	30-Apr	AD	Mike Swaney	1	95472	30	30 (1 d/year)	0
R8	14:00	30-Apr	AD	Don McEnhill	1	95448	40	193 (1/wk for 3 yr = 156+37/yr)	1
R9	15:45	30-Apr	AD	Peter Vilms	1	95404	25	75	1
R10	10:00	12-May	AD	Joan Vilms	1	95404	30	20	0

Survey No.	Survey time	Date	Pay or friend (p=1; f=0)	$ for shuttle	Place at RR respondent knows about	Reach area for boat questions	WD Individual visits canoes=left; other WC=right		WE Individual visits canoes=left; other WC=right		H Individual visits canoes=left; other WC=right	
R1	10:15	24-Apr	0	N/A	Healdsburg to ocean	Guerneville to Jenner	42	18	168	72	280	120
R2	11:45	25-Apr	0	NA	All of RR except Monte Rio, Duncan Mills, Cassini	All of RR except Monte Rio, Cassini	N/A	N/A	N/A	N/A	N/A	N/A
R3	14:25	25-Apr	0	N/A	Monte Rio to Jenner	Monte Rio to Jenner	30		80		200	
R4	10:15	28-Apr	N/A	N/A	Close to Jenner, River mouth area, Duncan Mills, Monte Rio to Jenner	Close to Jenner	10		20		40	
R5	10:30	28-Apr	0	N/A	Above Cloverdale all the way down	Healdsbury to Jenner (for the survey)	50		200		400	
R6	9:30	30-Apr	0	N/A	Healdsburg to Jenner	Healdsburg to Wohler Bridge, Guerneville, Monte Rio, Rian's beach	28.5		N/A	N/A	38	
R7	11:00	30-Apr	N/A	N/A	Healdsburg to Jenner	Healdsburg to Jenner	108	12	216	24	270	30
R8	14:00	30-Apr	0	N/A	Healdsburg to Forestville	Healdsburg to Forestville	36	24	144	96	360	240
R9	15:45	30-Apr	0	N/A	All except between Guerneville and Duncan Mills/ Monte Rio	All except between Guerneville and Duncans Mills/ Monte Rio	48	N/A	160	N/A	200	60
R10	10:00	12-May	N/A	N/A	Healdsburg to Steelhead beach, Duncans Mills to Jenner	Steelhead beach, Duncans Mills to Jenner	N/A	N/A	24	12	N/A	N/A

Survey No.	Survey time	Date	WD Individual visits swimmers=left; tubers=right		WE Individual visits swimmers=left; tubers=right		H Individual visits swimmers=left; tubers=right		Any records of use (yes=1; no=0)	May we look	Main destination on RR
R1	10:15	24-Apr	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	Hacienda Bridge to Guerneville; Guerneville to Monte Rio
R2	11:45	25-Apr	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	North of Healdsburg
R3	14:25	25-Apr	10		25		50		0	N/A	Monte Rio to Jenner
R4	10:15	28-Apr	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A, Sealwatch volunteers keep log, but takes time to research, unsure if possible	Jenner, Duncans Mills
R5	10:30	28-Apr	175		450		500		0	N/A	Depends upon the time of the year. Jenner when the flow is high. Healdsburg to Walnut Bridge- Sunset Beach, Guerneville, Monte Rio, Corbell, Summer Bridge
R6	9:30	30-Apr	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	Many variables
R7	11:00	30-Apr	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	Healdsburg to Jenner
R8	14:00	30-Apr	68	12	170	30	425	75	0	N/A	Hills near Healdsburg
R9	15:45	30-Apr	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	Launching near Memorial beach, Steelhead beach to R__ Dam/ Wohler, Duncans Mills to Jenner
R10	10:00	12-May	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	Between Duncans Mills and Jenner

Survey No.	Survey time	Date	Why
R1	10:15	24-Apr	lack of other boaters; play spots
R2	11:45	25-Apr	Fewer people, more interesting, faster flow, more flow
R3	14:25	25-Apr	More pristine, not built up (like upper section), cooler, more windy
R4	10:15	28-Apr	Depends on the weather. If it's cold and foggy near the ocean, it's Duncan Mills. If it's warm enough, it is Jenner.
R5	10:30	28-Apr	Close, no shuttle needed.
R6	9:30	30-Apr	N/A
R7	11:00	30-Apr	Better water for driftboats. For canoes, north of Healdsburg.
R8	14:00	30-Apr	Favorite place, know very well.
R9	15:45	30-Apr	Natural beauty, setting, wildlife, close to coast, ocean influence, nesting areas for birds
R10	10:00	12-May	Friends, easy to put in and take out kayak, park.

Survey No.	Survey time	Date	Why like	Attributes	Detect levels (yes=1; no=0)	Feeling (describe)	Pinpoint (describe)	Year(s) particularly low
R1	10:15	24-Apr	convenience for put in and take out; know river; wildlife viewing	solitude	1	N/A	own use pattern	N/A
R2	11:45	25-Apr	Doesn't smell	Very close (in the backyard)	1	N/A	Based on experience	Late 90s
R3	14:25	25-Apr	It's an outfitter, not crowded, relaxing	Close proximity	0	N/A	Based on experience	N/A
R4	10:15	28-Apr	Convenient, close to home, beautiful, blue heron nesting area.	Close	N/A	N/A	N/A	N/A
R5	10:30	28-Apr	It's home. Easy going. Diverse section of people. Open minded. It's gorgeous.	Beautiful, not in the city yet very convenient.	1	N/A	Based on experience	1995 (season started late)
R6	9:30	30-Apr	N/A	Accessibility, temperature of water, nice weather	1	N/A	N/A	N/A
R7	11:00	30-Apr	Close	Winter time fishing	0	N/A	Based on experience	1960s (sewage prob.)
R8	14:00	30-Apr	Above all the urban areas, closer, cleaner.	Grew up in the area, real attachment to the place.	1	N/A	Personal observation, talking to people.	Summer of 2002, 1976-77
R9	15:45	30-Apr	Natural beauty and setting, wildlife, close to coast, ocean influence, nesting areas for birds	Close, fabulous, easy access to a great esape. Not a long drive.	1	N/A	Observation	N/A
R10	10:00	12-May	Easy to put in and take out kayak, park. Love water. Wildlife. Opportunity to be with nature alone since there are fewer users due to fear of water.	Easy to put in and take out kayak, park. Love water. Wildlife. Opportunity to be with nature alone since there are fewer users due to fear of water. Natural and not developed/ engineered.	0	N/A	Havent noticed any difference.	N/A

Survey No.	Survey time	Date	Use % decrease	Visit during low flow (yes=1; no=0)	Portage (yes=1; no=0)	If Yes, Where	Infl. Kayaks (yes=1; no=0)	Release timing (yes=1; no=0)	What times?	Other (describe)
R1	10:15	24-Apr	N/A	1	0	N/A	0	1	N/A	N/A
R2	11:45	25-Apr	20	0	0	N/A	0	1	Weekends	N/A
R3	14:25	25-Apr	N/A	1	0	N/A	0	1	N/A	N/A
R4	10:15	28-Apr	N/A	0	0	N/A	0	1	Weekends, spring, fall	N/A
R5	10:30	28-Apr	20%	1	1	Probably at smaller sections of river, from Jenner to Duncans Mills.	1	1	Until the end of summer	N/A
R6	9:30	30-Apr	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
R7	11:00	30-Apr	N/A	1	0	0	0	0	N/A	N/A
R8	14:00	30-Apr	1/3rd	0	0	0	1	1	Weekends, holidays	
R9	15:45	30-Apr	N/A	0	1	Fr__ Road, Near Cassini Campground	1	1	N/A	Theater classes, different endevors, jazz festival on the river to divert attention from low flows.
R10	10:00	12-May	N/A	1	0	0	0	1	Best for fish. Mimick natural conditions.	Let it be natural

Survey results - Recreation Use

Survey No.	Survey time	Date	Low flow concerns (describe)	Contacts (yes=1; no=0)	Who (name and phone then revise contact list)	Questions/ Comments
R1	10:15	24-Apr	N/A	1	Directly marked contacts sheet during interview	Encourage flow regulations; improve public access; develop county auto tire disposal program; leave Guerneville Dam up longer
R2	11:45	25-Apr	Upriver, the conditions are worse. Conditions are OK from Healdsburg to Walder.	1	Directly marked contacts sheet during interview	
R3	14:25	25-Apr	Pollution, homeless people along the RR, human waste	1	Cassini's campground. Others in the list.	Aware of Sonoma County doing studies on the RR
R4	10:15	28-Apr	May be dangerous, obstructions may be a concern, may be a concern for the wildlife	1	Kayak rentals, Monte Rio Park (updated on list)	Understands the importance of the survey
R5	10:30	28-Apr	Low flow, scraping and dragging of kayaks -water crafts	1	Steve Jackson at King's, Monte Rio beach, Cassinis', local law enforcement log (updated)	Interested in the results
R6	9:30	30-Apr	N/A	N/A	N/A	N/A
R7	11:00	30-Apr	N/A	1	Burke's, Trowbridge (updated on list)	Purpose of survey
R8	14:00	30-Apr	Pollutants, bacteria, algae, human waste	1	Larry Laba at Soar Inflatables	N/A
R9	15:45	30-Apr	Pollution	1	Tom Meldau, (updated in list). Brian Hines (North Coast Solar Resources).	Curious about project.
R10	10:00	12-May	Low flow is dangerous and more difficult to navigate than high flow. People need to be educated to adapt to the river and leave it in natural conditions.	0	N/A	N/A

Survey No.	Survey time	Date	Researcher initials	Respondent's name	Business relevant? (yes=1; no=0)	Name & Location	No. of yrs	What do you do?	Place at RR respondent knows about	% of users day = left; overnight = right		% of customers using shuttle services	Paid (yes=1; no=0)	% paid	% of river use that is commercial
B1	14:25	25-Apr	AD	John Condon	1	CA Rivers Tours, 575 Country Club Dr, Santa Rosa CA 95401	6	Offer guided kayak tours	Monte Rio to Jenner	100%	N/A	0	N/A	N/A	N/A
B2	9:30	28-Apr	AD	Patrick Thomas Parks Jr	1	Prev. partner for Gold Coast Russian River Outfitters, 25375 Steelhead Blvd, Duncan Mills CA 95430	4	Rent Kayaks, adventure gears, retail for adventure wear	Close to Jenner	100%	N/A	N/A	N/A	N/A	50%
B3	11:30	30-Apr	AD	Ann Dwyer	1	CA Kayak Academy PO Box 2224, Windsor, CA 95492	3	Train people, tours, classes to Kayak	Healdsburg to Jenner	100%	N/A	N/A	N/A	N/A	N/A
B4	10:50	1-May	AD	Laura Wilson	1	Johnson's Beach Resort, 16241 1st St, Guerneville, CA 95446	36	Beach open to public, rent canoes and kayak. County boat launch on site too.	Guerneville	75	25	N/A	N/A	N/A	75% to 80%
B5	10:00	2-May	AD	Gina Cassini	1	Cassini's Campground, 22855 Moscow Rd, Jenner 95430 www.casiniranch.com	46	Campground near the river, rent canoes and kayaks	Near Jenner	N/A	100%	N/A	N/A	N/A	70%
B6	15:30	12-May	AD	Larry Laba	1	SOAR Inflatables, 20 Healdsburg Ave, Healdsburg, CA 95448	11	Produce inflatables for river running. One division of RR adventure (3 yrs) for guided and unguided trips	Healdsburg to Wohler Bridge	100%	N/A	100	N/A	N/A	N/A
B7	8:15	13-May	AD	Niki Rubin	1	West Coast Kayak, Close to Jenner	5	Guided tours	Close to Jenner	100%	N/A	N/A	N/A	N/A	N/A
B8	1:45	23-May	AD	Phil Wright	1	Trowbridge Canoe Trips, 13840 Healdsburg Ave, Healdsburg CA 95448	40	Owner. Rent canoes to paddle on river at various points.	Healdsburg to Jenner	90%	10%	90%	1	100%	75%
B9	10:50	27-May	AD	Shirley (manager for 6 yrs)	1	Mirabel RV Park Campground, 7600 River Road, Forestville, CA 95436	45	RV parking campground, rent canoes and kayaks	Forestville	N/A	N/A	0	N/A	N/A	N/A

Survey No.	Survey time	Date	WD Individual visits canoes=left; other WC=right		WE Individual visits canoes=left; other WC=right		H Individual visits canoes=left; other WC=right		WD Individual visits swimmers=left; tubers=right		WE Individual visits swimmers=left; tubers=right		H Individual visits swimmers=left; tubers=right		Any records of use (yes=1; no=0)	May we look	Origin of customers	Main destination on RR	Why
B1	14:25	25-Apr	30		80		200		10		25		50		0	N/A	90% are tourists	Monte Rio to Jenner	More pristine, not built up (like upper section), cooler, more windy
B2	9:30	28-Apr	14		40		40		N/A	N/A	N/A	N/A	N/A	N/A	1	N/A, havent contacted partner in 6 months	Mainly from San Francisco	East of Monte Rio	Weather, not as fickle, windy or foggy as near Jenner.
B3	11:30	30-Apr													1				
B4	10:50	1-May	50	24	100	50	100	50	250	N/A	500	N/A	750	N/A	0	N/A	San Francisco, Bay Area	Guerneville	Destination Resort Area
B5	10:00	2-May	24	20	40	15 to 20 kayaks, 10 rubber rafts	40	15 to 20 kayaks, 10 rubber rafts	N/A	N/A	N/A	N/A	N/A	N/A	1	N/A, no computer, too much time to look up	All over CA, Napa, Bay Area, out of state	Jenner. Campground is a destination park.	Nice campground.
B6	15:30	12-May	4	N/A	14	N/A	34	N/A	7	N/A	15	N/A	40	N/A	1	Yes. Numbers on sheet for May-Oct 02'	Majority from the Bay Area. Sometimes out-of-state.	6 miles downstream from Healdsburg	Offer trips only in one section. Convenient for business. Not a large crowd. Decent flow during summer.
B7	8:15	13-May	N/A	6	N/A	20	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	1	1, Wait! Call back	San Francisco	Guerneville	Burke's runs canoe trips. Johnsons Beach, Monte Rio have boats, sunny weather, and more public access.
B8	1:45	23-May	N/A	N/A	200	40	600	60	N/A	N/A	N/A	N/A	N/A	N/A	1	Yes. Called Sandy, waiting	Bay Area	Healdsburg	Majority of rentals/ canoes in the area
B9	10:50	27-May	N/A	N/A	20	16	20	16	N/A	N/A	N/A	N/A	N/A	N/A	0	N/A	All of the US, around the world	N/A	N/A

Survey No.	Survey time	Date	Why people choose your business?	Attributes	Detect levels (yes=1; no=0)	Feeling (describe)	Pinpoint (describe)	Year(s) particularily low	Use % decrease	Visit during low flow (yes=1; no=0)	Portage (yes=1; no=0)	If Yes, Where	Infl. Kayaks (yes=1; no=0)	Release timing (yes=1; no=0)
B1	14:25	25-Apr	Word-of-mouth, lot of referrals, marketing	Not crowded, relaxing	0	N/A	Based on experience	N/A	N/A	1	0	N/A	0	1
B2	9:30	28-Apr	Only one other Kayak company in the area, shuttle on weekend, for comfort	Not many homes and people, lots of wildlife, seals, trees, not much noise, little more private	0	N/A	Based on experience	N/A	N/A	1	0	N/A	0	1
B3	11:30	30-Apr												
B4	10:50	1-May	Less expensive than competitors, no rules/ regulations such as age limit, more relaxed. It's the only facility in the area.	Close to the city, relaxing, scenery, easy access	0	N/A	Based on experience	After 9/11, a little quiet	N/A	0	0	N/A	0	1
B5	10:00	2-May	Great location.	The river itself. Close to the river.	0	N/A	Based on experience	N/A	N/A	1	0	N/A	0	N/A
B6	15:30	12-May	Different. Inflatable boats.	Exclusive section on the river. Not many people. Great place for families to swim and play. Excellent bird life. Relatively short trip.	0	Only 3 yrs of experience	N/A	N/A	N/A	0	N/A	N/A	1	1
B7	8:15	13-May	Guided tours. People are scared so prefer guided tours. Many beginners. Wildlife in the area.	Serenity of the area.	1	No dams, no recreation	N/A	N/A	N/A	0	0	N/A	0	1
B8	1:45	23-May	Only operator. Business started in 1940/1950. Carried over several generations.	Recreation, flow in the river, esp. good for inexperienced people. Good for family, play and fun. Only 2/2.5 hrs from Bay Area.	1	N/A	Based on experience	Mid 1970s, last few years	10-15%	0	0	N/A	0	1
B9	10:50	27-May	Best RV park campground in the area	Canoes and kayak rentals, scenery	0	N/A	See the same number of people every year, doesn't decrease	N/A	N/A	0	0	N/A	0	0

Survey No.	Survey time	Date	If yes, what times?	Other (describe)	Low flow concerns (describe)	Contacts (yes=1; no=0)	Who (name and phone then revise contact list)	Questions/ Comments
B1	14:25	25-Apr	N/A	N/A	Polution, homeless people along the RR, human waste	1	Cassini's campground. Others in the list.	Aware of Sonoma County studying issues on RR
B2	9:30	28-Apr	N/A	Only local people would know. Tourists may not be aware.	Algal blooms, stinky	1	Monte Rio beach, kayak rentals, King's, state govt (updated on the list)	Purpose of the study
B3	11:30	30-Apr						
B4	10:50	1-May	When the river flow is very low	Dam installed at the property which pulls up water. Would be difficult without it.	Keep the dam operating	1	Burke's canoes (on the list)	SCWA has a dam upriver which is exempt from all rules and are less restricted, while dams not operated by SCWA have very stringent rules. The water flow was from May 15 to October 15 and now, it's changed to June 15 to October 1. Trying to address the issue.
B5	10:00	2-May	N/A	More water	Canoeing and Kayaking will diminish. Detrimental to the businesses. Fish kills and harm endangered species.	1	Monte Rio Beach, Guerneville Chamber of Commerce, Burke's and Trowbridge rental owners, Duncan Mills.	N/A
B6	15:30	12-May	If announced. Let people know about the releases.	Increase public access to river.	Reduction in use.	1	Trowbridge, Phil Wright 707-838-3200. Updated in the list.	Increase public access to the river.
B7	8:15	13-May	Summer. Depends upon the rain.	Water is important.	Risk to injury might be higher.	1	Steve Jackson at Kings (listed). John __ at Lotus Kayak Rentals near Jenner.	Asked upfront about the reason for the survey and the study.
B8	1:45	23-May	Summer- June, July, August	No reason to come to the river if the water level is too low.	No business.	1	Mirabel Park Campground, Burke's, SOAR Inflatables	When asked about mitigation, he mentioned, there can be no mitigation. Low water level is a killer. (Other comments during the interview)=More water should be held up in Mendocino and there should be reduced flow in May and more flow in the summer. There are storage problems and there is higher flow (1000 cfs) in May which is non-conducive for canoeing so cannot open to visitors. Appropriate flow for canoeing is between 300-650 cfs, where 300 cfs is very low and doesnt work well. Email report to wright2@sonic.net
B9	10:50	27-May	N/A	N/A	N/A	1	Burke's Canoes	N/A

Survey No.	Survey time	Date	Researcher initials	Respondent's name	Name of Agency and respondent's base	Full address	Mode of interaction with users/watercraft on RR	% of boaters day = left; overnight = right		Diff in other day and overnight user activities? (yes=1; no=0)	If yes, what diff?
A1	14:00	28-Apr	AD	Richard Edwards (Orville Hubbard)	Monte Rio Recreation and Park District in Monte Rio	20488 Hwy 116, Monte Rio CA 95462	Public beach, rentals, seasonal beach	100%	N/A		
A2	14:45	30-Apr	AD	Margaret Nelson	Russian River Chamber of Commerce and Visitor Center	16209 1st Street Guerneville, CA 95446	Public, tourists pick up brochures, contact for rentals, come in for information	20%	80%		50-50%
A3	9:10	30-May	AD	Bert Whitaker	Sonoma County Regional Parks	2300 Center County Drive, Suite 120A, Santa Rosa, CA 95403	Provide access points for public- Steelhead, Memorial, Healdsburg, Sunset Beach. Acreage park facility for people.(Info. from Healdsburg to Guerneville)	95-98%	N/A	1	Camping along sandy beaches, minimal impact on overnighters, More day users- litter/pollution

Sense of total use by % (yes=1; no=0)	If yes, unit?	How do you arrive at this estimate?	WD Individual visits canoes=left; other WC=right		WE Individual visits canoes=left; other WC=right		H Individual visits canoes=left; other WC=right		WD Individual visits swimmers=left; tubers=right		WE Individual visits swimmers=left; tubers=right		H Individual visits swimmers=left; tubers=right		Any records of use (yes=1; no=0)	May we look
1	Log sheet, people check in at the counter (call back)														1	call back
1	Number of people 12 to 20 every week	40 yrs of lifeguarding. Entrance for people-> site visit counts	3		18		75		40	N/A	70	N/A	350	N/A	1	Will Fax
							Steelhead Beach		20	N/A	35	N/A	175	N/A		
							Sunset Beach		20	N/A	35	N/A	175	N/A		

Use Calculation?	Any Zipcode information? (yes=1; no=0)	If no records, estimate the origin of visitors? (yes=1; no=0)	If yes, which areas?	Any use estimates between Healdsburg and Jenner? (yes=1; no=0)	If yes, can we obtain it? (yes=1; no=0)	Main destination?	Why?
	0	1	San Francisco, overseas			Forestville to Guerneville	Dams, people go around the dam, come for play and fun, no serious activities
Lifeguard Statistics	0	0	N/A	0	N/A	Guerneville to Monte Rio	Access points, drive ways, portage is straightforward

Why this destination?
Close to Bay area and SF, cheaper, ~12 miles from the ocean, hiking close
Gorgeous, beautiful river.

Imp. attributes to watercraft users in RR area?	Detect levels (yes=1; no=0)	Feeling (describe)	Pinpoint (describe)	Year(s) particularily low	Use % decrease	Visit during low flow (yes=1; no=0)	Portage (yes=1; no=0)	If Yes, Where	Infl. Kayaks (yes=1; no=0)
Beauty of the place, old area, established with families, some people have relatives.							0	N/A	1
Water safety, preparedness.	Depends upon the weather	N/A	Observation that weather is the major deciding factor	N/A	N/A	0	0	N/A	0

Release timing (yes=1; no=0)	Other (describe)	Low flow concerns (describe)	Demand for salmonid fishing (high=1; low=0)	Demand for bass fishing (high=1; low=0)	Contacts (yes=1; no=0)	Who (name and phone then revise contact list)	Questions/ Comments
N/A	N/A	N/A	1				
N/A	Increase public access	Water quality issues, beach closures result due to pollution (E.coli), Public safety	N/A	N/A	1	CA permanent lifeguards patrol beaches. Contact state for numbers- info for fishing. Local fish and game warden - RR watershed.	Asked about who I work with and who I work with at SCWA?

APPENDIX E

ECONOMIC ANALYSIS FOR THE RUSSIAN RIVER BIOLOGICAL ASSESSMENT

ECONOMIC ANALYSIS FOR THE RUSSIAN RIVER BIOLOGICAL ASSESSMENT

Prepared for:

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Term	***Definition***
AF	acre feet
BA	Biological Assessment
CDFG	California Department of Fish and Game
cfs	cubic feet per second
D1610	Decision 1610
D1610-Current	Minimum instream flows set under SWRCB D1610
ESU	evolutionarily significant unit
FERC	Federal Energy Regulatory Commission
FP-75%	Flow proposal with no measures at 75% buildout
FP-Buildout	Flow proposal at future demand level with no additional water supply measure.
FP-Current	Flow proposal with no measures under current conditions
I-O	input-output model
IMPLAN	Economic impact analysis planning modeling software
M&I	municipal and industrial
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation District
MIG	Minnesota IMPLAN Group, Inc.
MW	megawatts
MW/day	megawatts per day
NEA	Northwest Economic Associates
N.E.C.	Not elsewhere classified
NMFS	National Marine Fisheries Service (now NOAA Fisheries)
NOAA Fisheries	the National Oceanic and Atmospheric Administration Fisheries (formerly, NMFS)

Term	***Definition***
PG&E	Pacific Gas & Electric Co.
PVID	Potter Valley Irrigation District
REIS	Regional Economic Information System (U.S. Department of Commerce)
RPC	Regional Purchase Coefficients
RVCWD	Redwood Valley County Water District
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
USACE	U.S. Army Corps of Engineers

1.0
INTRODUCTION

1.1 PURPOSE AND SCOPE

The purpose of this economic analysis is to evaluate the economic implications of changes to project operations and potential flow scenarios evaluated in the ENTRIX, Inc. 2004 *Russian River Biological Assessment* (BA).[1] Evaluation of economic effects of the proposed operations will assist the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (SCWA), and NOAA Fisheries in selecting appropriate measures and evaluating the proposed alternative project operations.

The scope of the economic analysis includes Sonoma and Mendocino counties in California. The two counties contain nearly the entire Russian River basin. Economic effects were measured for reservoir (Lake Sonoma and Lake Mendocino) and river-based (Russian River) recreation, energy production at affected hydroelectric generating facilities, and regional impacts in both Sonoma and Mendocino counties. However, positive economic impacts such as those associated with construction of a pipeline from Warm Springs Dam to Dry Creek were not measured.

This report incorporates the results of an analysis by ENTRIX, Inc. of recreation on the Lower Russian River.[2] This report extends the analysis by examining impacts in the Upper Reach of the Russian River as well as in the two reservoirs.

1.2 REPORT ORGANIZATION

This report is contained in five sections. The section following this introduction provides the method and approach to measuring economic impacts. It begins with a description of the water system of the Russian River. The types of economic effects are described, including distinctions made for regional versus direct impacts. The definition of “current” and “full buildout” is provided as it applies to water demands, specifically for measuring impacts in Sonoma County. Finally, methods for measuring impacts on recreation and hydroelectric power generation are described.

The third section provides a baseline description of the current conditions in both Sonoma and Mendocino counties. The current economic base is provided for context to interpret impacts. Included in this section is an overview of primary water use and users, including agricultural irrigation and recreation. As will be noted later, impacts to agriculture of the proposed action is nonexistent, as the project considered in the BA does not change the water supply to irrigators. A description of recreational water use in

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[1] ENTRIX, Inc., *Russian River Biological Assessment*, prepared for USACE and SCWA, September 29, 2004.

[2] ENTRIX, Inc., “Preliminary Recreation Assessment for the Flow Proposal,” Appendix D, *Russian River Biological Assessment*, September 29, 2004.

Sonoma County is provided. The section ends with discussion of the economic base, water use, and recreation in Mendocino County.

The fourth section presents the impacts of the proposed action in the categories of recreation, hydroelectric power generation, and regional impacts. Results are provided for the flow proposal with additional measures, as compared to the baseline. The final section of the report contains a summary and conclusions of the economic impacts, as well as implications.

2.1 DESCRIPTION OF THE WATER SYSTEM

2.1.1 HYDROLOGY

A detailed discussion of the hydrology of the Russian River is presented in the 2004 ENTRIX, Inc. *Russian River Biological Assessment.*[3] The following brief discussion of the operation of the system is provided as background for measuring impacts on recreation, agriculture, and hydroelectric power production.[4]

Three major reservoir projects provide water supply storage for the Russian River watershed (see Figure 2-1): Lake Pillsbury, Lake Mendocino, and Lake Sonoma.[5] Lake Pillsbury is located on the Eel River and is formed by Scott Dam. Water is released from the lake to the Eel River and is diverted at Cape Horn Dam to Pacific Gas and Electric Company's (PG&E's) Potter Valley Power Plant through a diversion tunnel. The water flows through Potter Valley in the East Fork Russian River.

Lake Mendocino is part of the Coyote Valley Dam Project and is impounded by Coyote Valley Dam on the East Fork Russian River. The multipurpose facility provides hydroelectric power, flood protection, recreation, and irrigation and domestic water supplies. SCWA and Mendocino County Russian River Flood Control and Water Conservation District (MCRRFCD) share California water rights permits to store up to 122,500 acre feet (AF) in the reservoir. SCWA controls releases from the 69,000 AF water supply pool in the reservoir.

Lake Sonoma is impounded by Warm Springs Dam at the confluence of Dry Creek and Warm Springs Creek. The multipurpose facility provides flood protection, recreation, and a fish hatchery. SCWA, under contract with the federal government, uses 212,000 AF of water supply storage space in the lake. That contract gives SCWA the right to control the rate of release of water from the water supply pool.

Lakes Mendocino and Sonoma are collectively called the "Russian River Project" and releases from the reservoirs are determined by Decision 1610 (D1610). That decision established instream flow requirements for Dry Creek and the Russian River. The Russian River flow requirements between Lake Mendocino and Dry Creek were set according to the assumption that all water supply available from Lake Mendocino would

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3 ENTRIX, Inc., *Russian River Biological Assessment*, prepared for USACE and SCWA, September 29, 2004.

4 Beach, Robert F., *The Russian River: An Assessment of Its Condition and Governmental Oversight*, prepared for Sonoma County Water Agency, August 1996.

5 Sonoma County Water Agency, *Water Supply and Transmission System Project, Draft Environmental Impact Report, Volume I*, September 1996.

be available to satisfy instream flow needs between that lake and Dry Creek as well as expected diversions on that reach of the Russian River. The Russian River flow requirements downstream from the confluence with Dry Creek during *normal* water supply conditions were based primarily on a desire to maintain flows for recreational canoeing on the Russian River. Reduced flows for *dry* and *critical* water supply conditions were based on warmwater fish and wildlife needs. Instream flow requirements for Dry Creek were set to meet fish spawning, passage, and rearing needs determined by the California Department of Fish and Game (CDFG).

2.1.2 Water Management

SCWA was created in 1949. SCWA's activities include producing and delivering potable water for municipal and industrial uses, managing flood and storm waters, providing sanitary sewage services, and providing recreational services associated with its flood control and water conservation activities. SCWA delivers water to customers through its water transmission system. The primary water users, known collectively as the water contractors, consist of the cities of Santa Rosa, Rohnert Part, Petaluma, Cotati, and Sonoma; and the North Marin, Valley of the Moon, and the Forestville Water Districts. SCWA also provides water to the Marin Municipal Water District, the Town of Windsor, and the Lawndale Mutual, Penngrove, and Kenwood water companies.[6]

2.2 Defining Economic Impacts

Regional economic impact analysis provides for the measurement of income, industry sales, and employment adjustments that occur as a result of changes in the demand for regionally produced goods and services. Measures of economic impacts are generally developed to provide an indication of modifications in the level of economic activity caused by resource changes within a region. Among the most common measures of economic impacts are jobs, employment earnings, total personal income, and industry outputs associated with the sale of goods and services. Depending on whether the resource adjustments include increases or decreases in the demand for local products, changes in the economic impact measures may be either positive or negative.

The impact measures are generally developed to provide an indication of the relative magnitude of changes to economic activity in a region. Increases or decreases in the sales of goods and services provide an overall indication of the impacts to regional economic activity. Economic impact models were developed for Mendocino and Sonoma counties so that the economic effects of changes in crop production, recreation activity, and hydropower production resulting from changes in river flows and reservoir levels could be quantified.

6 Sonoma County Water Agency, "Urban Water Management Plan 2000."

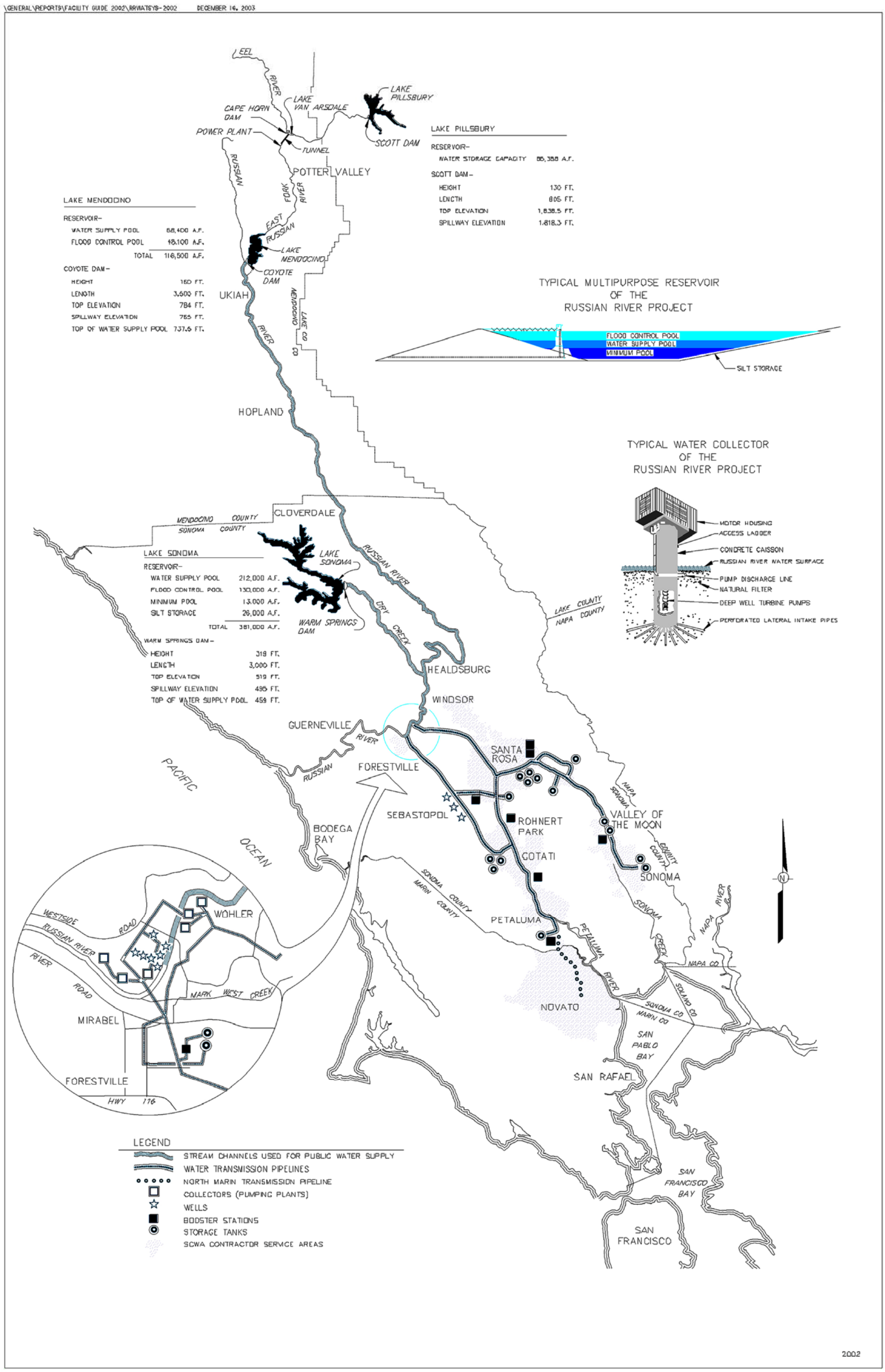

Figure 2-1 The Russian River Water System General Location Map

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One of the most commonly used methods of quantifying regional economic changes is through the use of an input-output (I-O) model. A business is linked to the regional economy through its purchase of inputs required to produce goods and services and through the sales of these goods to other businesses in the local area. The I-O model includes detailed information on the purchases of production inputs from local business, purchases of inputs from outside the region, purchases of labor inputs, and payments to management and ownership.

2.2.1 Direct Effects

Because the businesses within a local economy are linked together through the purchase and sales patterns of goods and services produced in the local area, an action which has a direct impact on one or more local industries is likely to have an indirect impact on many other businesses in the region. Direct impacts are the change in industry sales. These sales can be either for inputs to other industries in the region, or for final consumption by households and government in the region, or for exports from the region.

For example, a decline in the production of wheat (a direct impact) will lead to a reduction in spending in the local area as farms reduce production. Moreover, firms providing production inputs and support services to the farms would see a decline in their industry outputs as the demand for their products also declines. These additional effects are known as the indirect economic impacts. As household income is affected by the reductions in regional economic activity, additional impacts occur. The additional effects generated by reduced household spending are known as induced economic impacts.

Measuring impacts for recreation and tourism is different from the single-industry example given above. Expenditures for these activities occur in a number of industries. Typically, tourists pursuing recreation activities will spend money on food, other retail, gasoline, and possibly lodging.

Measuring the direct impacts is a key step in analyzing the impacts on a regional economy. Frequently, the impacts are measured in physical quantities, such as the change in the quantity of a crop that is produced or in the quantity of power generated. These physical quantities must be converted to a sales value for introduction to the I-O model. For recreation, an expenditure pattern needs to be identified that reflects how various categories of visitors, such as day users or those that stay overnight, spend money during their visit. It is important to identify only those expenditures related to the recreational activity of concern that actually occurs in the impact area, and exclude those expenditures that occur outside the impact area.

2.2.2 Regional Impacts

These I-O models are used to measure the direct, indirect, and induced linkages within a regional economy. The tool most often used to measure these interrelationships is known as a multiplier. An I-O model generates a variety of multipliers and each is associated with a specific industry. A multiplier is a single number that quantifies the total economic effects (for all businesses) which arise from direct changes in the economic activity of a single industry. Multipliers can be generated to measure the total output, income, and employment effects associated with changes in the demand for regional goods and services. For example, an output multiplier of 2.5 for the fruit industry would indicate that a $100,000 decline in sales by this industry would lead to an overall decline of $250,000 in business sales throughout the economy, including the initial $100,000 loss to the fruit sector. An employment multiplier of 2.0 for the railroad industry would indicate that a loss of 10 jobs in this sector would lead to an additional loss of 10 jobs in other industries for a total loss of 20 jobs throughout the regional economy. In the case of recreation, the direct effects occur over a number of sectors and the aggregate of the multipliers is generally used as an indication of the overall effect of recreation.

2.3 DEFINING THE BASELINE

For the purposes of this economic analysis, the baseline against which impacts are measured reflects current economic conditions, industrial base, and water use. "Current conditions" are more precisely defined by the most recent available information, and for most socioeconomic elements is the year 2000. These data are articulated in the next section of this report, "Water in the Regional Economy."

2.3.1 FULL BUILDOUT

The California Water Code, Sections 10610 et seq., requires water agencies to prepare a regional Urban Water Management Plan, to quantify past and current use, and to quantify anticipated future water use to 20 years out.[7] The projection is used to demonstrate whether water supplies are adequate for the next 20-year planning period.

In the *Russian River Biological Assessment*,[8] a "D1610 at buildout" (i.e., full buildout) alternative is considered whereby demand for water in the future is considered. The economic analysis also contains analysis of the full buildout alternative; however, no effort was made to attempt to project *economic conditions* into the future, including any growth that might ensue as a direct result of increased water supplies. That is, income and industrial output by economic sector remains unchanged from current conditions. Therefore, the analysis of economic effects is presented as if the future demand for water must be accounted for today. Operationally, the full buildout alternative considers water deliveries by SCWA for municipal and industrial purposes in the year 2020.

The full buildout scenario applies only to water demand and projections affecting SCWA. There is no equivalent future projection of water use that applies to Mendocino County or MCRRFCD.

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7 California Water Code §10631, as cited in Sonoma County Water Agency, "Urban Water Management Plan 2000," p. 4-1.

8 ENTRIX, Inc., "Alternative Actions," Appendix A to the *Russian River Biological Assessment*, prepared for Sonoma County Water Agency, September 29, 2004.

2.4 MEASURING IMPACTS

2.4.1 RECREATION

Recreation activities may be affected by the flow proposal through changes in water management methods that affect lake levels and river flows. Changes in lake levels affect recreation activities primarily by reducing access to boat ramps, swim beaches, marinas, campgrounds, etc. Access can be reduced by lake levels that are either too high or too low.

Storage volumes and related lake levels were projected by SCWA for the baseline and the flow proposal for both Lake Sonoma and Lake Mendocino. Thresholds for access were estimated through consultation with lake facilities managers.[9] For Lake Mendocino, the high threshold range was estimated at 749 to 755 feet above sea level and the low range at 725 to 726 feet above sea level. For Lake Sonoma, the high threshold range was 451 to 490 feet above sea level and the low range was 325 to 427 feet above sea level.

These values were then compared to projected lake elevations for the baseline and for the flow proposal for both lakes. This comparison was made at the low value of the high range and the high value of the low range for both lakes.

A similar process was followed for river flows. In this case, only low flows were of concern, particularly as they affected canoeing and other watercraft use. ENTRIX provided a threshold level for the Lower Russian River of 140 cubic feet per second (cfs).[10] Details about how the assumption was developed for a minimum boatable flow are found in Appendix D, Section D.3.3.1. Flow value projections for the baseline and the flow proposal were provided by SCWA for the river reach between Cloverdale and Healdsburg. A comparison was then made with this threshold and monthly average flow levels during the prime recreation season (May through September) to identify those months when average monthly flows fell below the 140-cfs threshold. The 140-cfs threshold level was also applied to recreation on the Upper Reach of the Russian River.

2.4.2 HYDROELECTRIC POWER GENERATION

Changes in water management as a result of the flow proposal can change the pattern of historic releases from Lake Sonoma and Lake Mendocino, which in turn could affect the amount of power generated compared to current conditions. Monthly flows were developed for the baseline and each phase of the flow proposal for each power facility. The methods below describe how the monthly flow data were used in conjunction with data on generator operation and capacity and power prices to estimate changes in the value of power produced for the baseline (i.e., D1610 current) and for each flow phase or

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9 Williams, Charles, dam operator and maintenance, Lake Mendocino, and Atchison, Mike, Park Manager, Lake Sonoma, personal communication, June 2, 2003 and May 2, 2003.

10 ENTRIX, Inc. "Recreation Assessment for the Russian River Biological Assessment," Appendix D, Attachment 6, *Russian River Biological Assessment*, September 29, 2004.

scenarios as identified in the *Russian River Biological Assessment* (Section 4.3, Water Management)[11] and Appendix A[12] to the *Russian River Biological Assessment*.

Average daily flows from January 1999 to May 2003 were provided by SCWA. From this record, daily flows were grouped into the categories shown in Table 2-1 in the cfs column. The average megawatts per day (MW/day) for each category were estimated and are shown in the MW/day column. The averages reflect days when flows were suitable for power generation but the generators were not operated or were operated for less than the full 24 hours.

Table 2-1 Operating Rules for Warm Springs Hydroelectric Facility, Lake Sonoma

Cubic Feet per Second (cfs)	MW/Day	No. of Days
<75	0	19
75-84	30.42	80
85-94	30.04	276
95-104	31.65	171
105-114	34.12	250
115-124	38.35	136
125-134	43.28	156
135-144	42.36	64
145-154	54.82	67
155-164	52.64	39
165-174	51.47	53
175-180	54.76	43
>180	55.68	232

The method used for estimating the value of power for Lake Sonoma begins with multiplying a value from the MW/day column of the table below that corresponds to a monthly flow value times the number of days in the month to determine the MW/month for that month. This was then multiplied by the summer or winter energy payment per hour, depending upon the month in question. To this value was added the summer or winter capacity payment to provide an estimate of the value of the power produced for the month.

The method for computing power generation from flow data was as follows:

For monthly flows below 75 cfs, the MW/day value is 0, and the value of power produced for such a month is the value of the capacity payment. This assumes that even though average flows during the month were estimated to be below 75 cfs, the variation in flows within the month would result in the minimum contract power requirement being

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11 ENTRIX, Inc., *Russian River Biological Assessment*, prepared for USACE and SCWA, September 29, 2004.

12 ENTRIX, Inc., "Alternative Actions," Appendix A to the *Russian River Biological Assessment*, September 29, 2004.

met. According to the data presented in Table 2-1, this was the case between January 1999 and May 2003. Although this assumption may not hold over a longer time period, it is valid for comparisons between the baseline and proposed flow phases.[13] For all other monthly flows, the value for MW/day is that presented in the table. The value above 180 cfs reflects the maximum historical operating capacity.

The method of computing power generation for Lake Mendocino from the flow data was similar to that used for Lake Sonoma and was as follows:

- If average monthly flows were below 125 cfs, no power was generated.
- Between 125 cfs and 400 cfs, the cfs was multiplied by the power generated per cfs per day (0.171) times the number of days in the month times the price ($65/ per megawatts [MW]).
- For flows over 400 cfs up to 2,000 cfs, the generators were considered to operate at maximum capacity (68.4 MW/day). The MW/day were multiplied by the days per month times the price.
- Above 2,000 cfs, releases were diverted around the penstocks and no power was generated.

2.4.3 Regional Impacts

Visitor day-impacts for paddlers were also estimated and the I-O model was used to estimate the economic impact on Sonoma County. Visitor expenditure profiles for commercial and private users, further divided into day use and overnight visits, were established. Multiplying the number of visits in these categories by the expenditure patterns provided an estimate of the direct effect of the change in number of visits from the baseline. The direct effect was then entered into the I-O model as a change in final demand and the indirect, induced, and total effects on the county economy were estimated.

[13] In periods of extreme drought, it is possible that even the minimum contract generating requirement may not be met in a particular month. Such a circumstance would affect both the baseline and flow proposal phases. The relevant issue is whether the incidence would occur *more often* under any of the flow phases. Such an analysis was not done, but is not thought to be prevalent, if at all, and the measured economic impact would be relatively small.

3.1 ECONOMY OF SONOMA COUNTY

3.1.1 CURRENT ECONOMIC BASE

An I-O model was developed for each of the two impacted counties using IMPLAN data and software, discussed in more detail in Attachment 1. The base data for Sonoma County, which provides a "snapshot" of the local economy, are displayed in Table 3-1. Over $28.5 billion in goods and services are produced within Sonoma County, with local industry supporting nearly 272,000 jobs and earnings of nearly $11 billion. In terms of output, manufacturing is the largest industry, contributing over $7.4 billion, or over a quarter of the county's total industry output. The largest employer in Sonoma County, Agilent Technologies, Inc., manufactures measuring and controlling devices and most recently employed a total of 3,900 people at locations in Santa Rosa and Rohnert Park.[14]

Table 3-1 Sonoma County IMPLAN Model Base Data

Industry	Output *($millions)*	Income *($millions)*	Employment *(# of jobs)*
Agriculture, Forestry, and Fishing	$618.665	$310.644	14,414
Mining	$194.408	$40.115	502
Construction	$3,505.733	$1,397.892	23,996
Manufacturing	$7,407.369	$2,160.225	33,682
Transportation, Communication, and Public Utilities	$1,756.869	$396.841	7,869
Trade (Retail and Wholesale)	$3,295.213	$1,512.992	52,637
Finance, Insurance, and Real Estate	$4,583.628	$839.103	20,587
Services	$5,498.612	$2,865.457	85,015
Government	$1,604.243	$1,273.254	28,576
Other[1]	$35.490	$36.356	3,501
Total	**$28,500.229**	**$10,832.879**	**270,780**

[1] For this model, "other" consists primarily of domestic services (such as cleaning and maid services), as well as an "inventory valuation adjustment," used to estimate the value of goods removed from inventory that were produced in a previous time period at a different value.

Source: 2000 IMPLAN data from Minnesota IMPLAN Group, Inc., with modifications by Northwest Economic Associates.

Other significant manufacturing firms located in Sonoma County include Medtronic, Inc., which employs 1,700 and produces medical instruments and supplies, and JDS Uniphase

[14] Sonoma County Economic Development Board, in partnership with Sonoma County Workforce Investment Board, *Economic Development Board: Local Economic Report Series*, Vol. 2, Issue 1, Spring 2003.

Corporation, which designs and manufactures communications equipment and employs 990.[15]

The services sector is the largest in the county in terms of employment, with over 85,000 jobs, accounting for more than 30 percent of total employment. Services include a wide variety of businesses providing services to other businesses, individuals, government, and other organizations, such as lodging, health, or legal service providers. IMPLAN does not include an explicit recreation industry; expenditures from recreation are made in a number of sectors. Top employers in the services sector in Sonoma County include St. Joseph Health System, with 1,400 employees, Sutter Medical Center, with over 700 employees, and the Sonoma Mission Inn and Spa, a resort hotel with 700 employees.[16] Trade, which includes both retail and wholesale, is also a significant employer, with more than 52,000 jobs in the county. Long's Drug Stores, a retail chain, employs over 700 people in Sonoma County.[17] Agriculture, discussed in more detail below, is an important element of the county economy, as Sonoma County is a key producer of wine and other farm products.

3.1.1.1 Population

Age, race, and ethnic characteristics of the Sonoma County population, as recorded by the 2000 Census, are presented in Table 3-2. A total of 458,614 people lived within the county in 2000. The distribution among age groups is fairly typical of the state of California, except for a slightly larger percentage of county residents over the age of 65 (13 percent) compared to less than 11 percent for the state.[18]

The county population is predominantly white, with 82 percent of those counted by the 2000 Census identifying themselves as white. The next largest group, which accounts for 8 percent of the county population, includes those who selected "some other race." Because the 2000 Census allowed the selection of more than one race for each person, another 4 percent of the population selected "two or more races."

Hispanic origin is tallied separately from race, as a person of Hispanic origin can be of any race. Just 17 percent of the county's population identified themselves as being of Hispanic origin in the 2000 Census, as compared to 32 percent of the state population.[19]

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15 Ibid.

16 Ibid.

17 Ibid.

18 U.S. Census Bureau, Census 2000, *Table DP-1 Profile of General Demographic Characteristics: 2000*, Geographic Area: California.

19 Ibid.

Table 3-2 Age, Race, and Ethnicity Characteristics of Sonoma County Population (2000)

Age, Race, and Ethnicity Characteristics	Number of People	Percentage of County Total
Age Group (Years)		
0 to 19 years	124,835	27%
20 to 34 years	86,212	19%
35 to 44 years	75,615	16%
45 to 54 years	73,837	16%
55 to 64 years	40,138	9%
65 years and over	57,977	13%
Race		
White	374,209	82%
Black or African American	6,522	1%
American Indian and Alaska Native	5,389	1%
Asian	14,098	3%
Native Hawaiian and Other Pacific Islander	934	<1%
Some Other Race	38,717	8%
Two or More Races	18,745	4%
Hispanic Origin		
Hispanic	79,511	17%
Non-Hispanic	379,103	83%
Total Population	**458,614**	**100%**

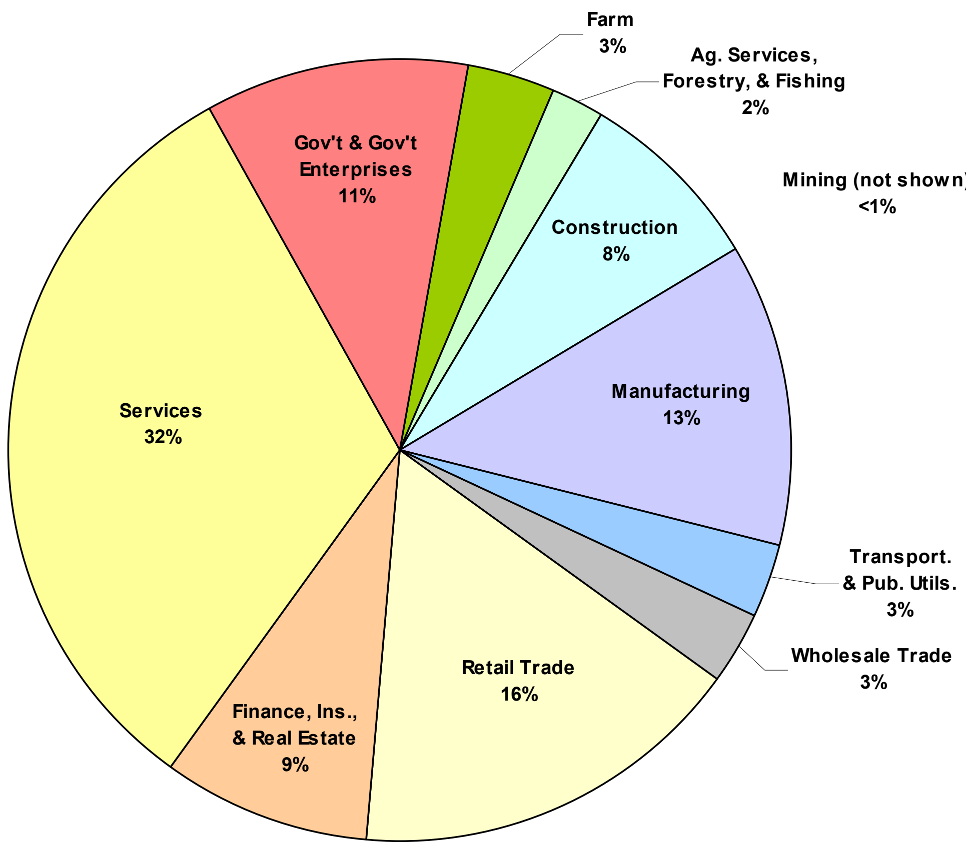
Note: Percentages may not appear to add to 100 due to rounding.
Source: U.S. Census Bureau, Census 2000, *Table DP-1 Profile of General Demographic Characteristics: 2000,* Geographic Area: Sonoma County, California.

Most of the residents of Sonoma County live within one of its several cities, as shown in Table 3-3. Santa Rosa is the largest city in the county, with a population of 147,595, or 32 percent of the county's residents.

Table 3-3 Sonoma County Cities and Population (2000)

City	Number of People	Percentage of County Total
Cloverdale	6,831	1%
Cotati	6,471	1%
Healdsburg	10,722	2%
Petaluma	54,548	12%
Rohnert Park	42,236	9%
Santa Rosa	147,595	32%
Sebastopol	7,774	2%
Sonoma	9,128	2%
Windsor	22,744	5%
Incorporated	**308,049**	**67%**
Unincorporated	**150,565**	**33%**

Source: California Department of Finance, Revised Historical City, County, and State Population Estimates, 1991 to 2000, with 1990 and 2000 Census Counts, March 2002.



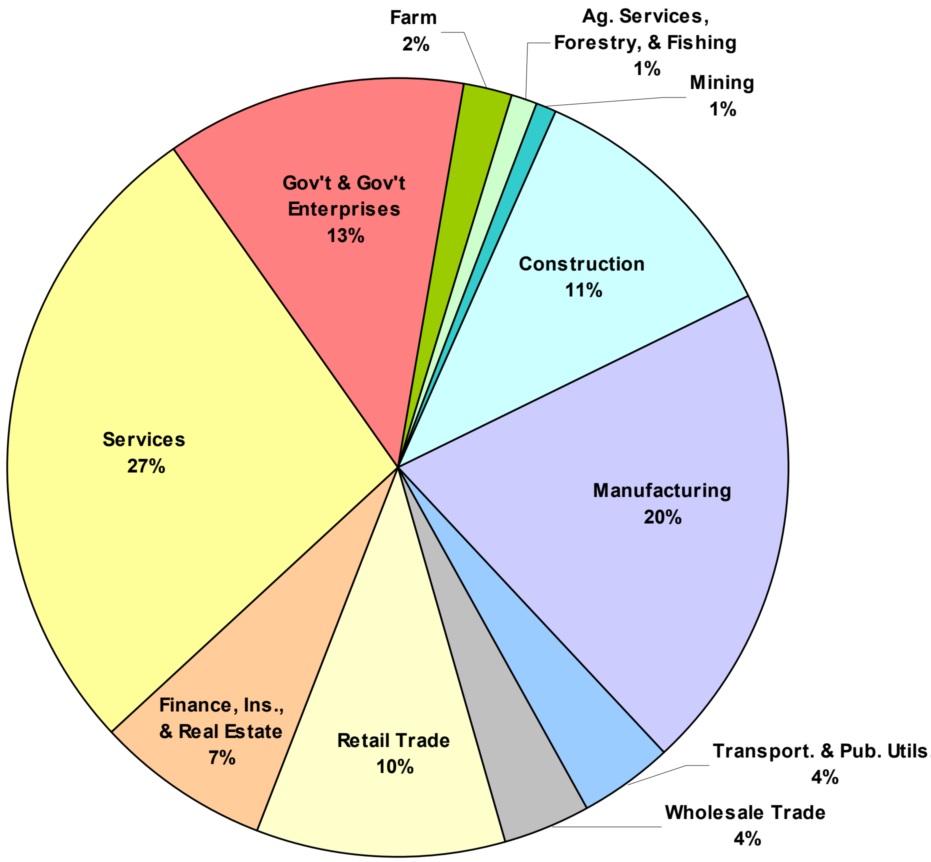
Source: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Economic Information System (REIS), 1969 to 2000*, CD-ROM, May 2002.

Figure 3-1 Sonoma County Employment by Industry (2000)

3.1.1.2 Employment and Earnings

Employment and earnings by industry are presented in Figures 3-1 and 3-2. These employment numbers from the Department of Commerce's Regional Economic Information System (REIS) count all jobs, including nonagricultural wage and salary employment, agricultural employment, and nonagricultural jobs that are not covered by state unemployment insurance, such as the self-employed. These numbers may differ slightly from the IMPLAN model data, which are compiled from a number of sources.

Employment in the services sector accounts for nearly one-third of all employment in Sonoma County. Other significant employers include retail trade, with 16 percent of the jobs, manufacturing, with 13 percent, and government and government enterprises, with 11 percent. Agricultural employment on farms and in agricultural services, forestry, and fishing contributes approximately 5 percent of the county's total employment.



Source: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, Regional Economic Information System (REIS), 1969 to 2000, CD-ROM, May 2002.

Figure 3-2 Sonoma County Earnings by Industry (2000)

Earnings represent the sum of three components of personal income: wage and salary disbursements, other labor income (includes employer contribution to pension and profit-sharing, health and life insurance, and other non-cash compensation), and proprietors' income. Earnings reflect the amount of income that is derived directly from work and work-related factors. Earnings can be used as a proxy for the income that is generated within a geographical area by industry sectors, and can be used to identify the significant income-producing industries of a region or to show trends in industry growth or decline.

The services sector is also Sonoma County's largest in terms of earnings, but with a smaller share than for employment, at just 27 percent. Earnings for retail trade also decreased compared to the share of employment, as 16 percent of the jobs contribute only 10 percent of the earnings. The preponderance of part-time workers in the services and trade sectors, as well as the tendency for wages in these industries to be lower than others, likely affects the earnings figures. While manufacturing accounted for just 13 percent of the jobs, earnings in this industry contribute 20 percent of the county's total, due to the greater pay these jobs usually garner.

The labor force is made up of all persons 16 years of age or older within a specific geographic area who are either working or actively looking for work. The unemployment rate is the percentage of people within this labor force who are not employed, but still actively seeking work. The unemployment rate for the past several years has been lower for Sonoma County than for the state of California, suggesting greater opportunities for employment have existed in the county than for the entire state. In 2002, the annual average unemployment rate was 4.5 percent in Sonoma County,[20] compared to 6.7 percent for the state of California.[21] The lowest unemployment rate in recent years for the county was 2.6 percent in 2000.[22]

3.1.1.3 Economic Well-Being

Personal income is another indicator of a region's economic vitality. Personal income encompasses not only earnings, such as wages and salaries and other work-related compensation as discussed previously, but also transfer payments and investment income. Transfer payments are comprised of payments such as income maintenance, unemployment insurance, retirement benefits, and medical payments. Investment income includes interest, dividends, and rent from investments.

Per capita income is calculated by dividing the total personal income by the total population for a particular area. This figure can be used to compare regions or time periods, and is a useful indicator of the character of consumer markets and the overall economic "well-being" of area residents. Per capita income provides a good measure of how personal income is growing relative to a population, but does not necessarily indicate how that income is distributed among the population.

Sonoma County's per capita income in 2000 was \$35,193, which was somewhat greater than that of the state of California, at \$32,363.[23] Sonoma County ranked 10th of California's 58 counties in terms of per capita income, with Marin County reporting the highest, at \$62,927.[24]

Another measure used to indicate economic well-being in a region is the percentage of people who are estimated to live below the poverty level. These data are based on national levels set for minimum income requirements for various different sizes of households. There is no correction for the variation in costs of living among areas. For example, if housing prices and food prices in a county were lower than national levels, then a family in that county with an income at the national poverty level might be better

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20 California Employment Development Department, Labor Market Information Division, "Civilian Labor Force, Employment, and Unemployment — Updated 5/7/2003," for Sonoma County.

21 California Employment Development Department, Labor Market Information Division, "Civilian Labor Force, Employment, and Unemployment — Updated 5/7/2003," for California State.

22 California Employment Development Department, Labor Market Information Division, "Civilian Labor Force, Employment, and Unemployment — Updated 5/7/2003," for Sonoma County.

23 U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Economic Information System (REIS), 1969-2000*, CD-ROM, May 2002.

24 Ibid.

off than a family with the same income living elsewhere in the nation. However, poverty figures can be useful to permit comparison between geographic areas and time periods.

The most recent available poverty data are from the 2000 Census, and are based on income levels reported for 1999. In 1999, 5,340 families in Sonoma County were found to have incomes below the poverty level, representing 4.7 percent of all families in the county for which poverty status was determined.[25] This is much lower than the 10.6 percent of families living in poverty that was reported for the state of California.[26] When individual people are counted, 36,349, or 8.1 percent, of the Sonoma County residents for which poverty status was determined lived below the poverty level in 1999.[27] This is also a far lower rate than that of the state, which reported that 14.2 percent of individuals for which poverty status was determined had incomes below the poverty level in 1999.[28]

3.1.2 Municipal and Industrial Water Use and Needs

SCWA is the purveyor of wholesale water to municipal and industrial (M&I) water users in Sonoma County and parts of Marin County. Water distributed in the recent past, and projections of future needs, are presented in Table 3-4. In 2000, SCWA delivered 60,692 AF to water contractors and other users. The largest single customer is the City of Santa Rosa, at approximately 23,000 AF in 2000.[29]

Table 3-4 Wholesale Water Distribution, Sonoma County Water Agency (AF)

Distribution	1990	1995	2000	2005	2010	2015	2020
Water Contractors	46,366	47,974	51,751	56,692	68,502	70,094	70,824
Other Users	5,073	5,670	8,941	10,378	11,458	12,650	13,967
Total	51,439	53,644	60,692	70,070	79,960	82,744	84,791

Source: Sonoma County Water Agency, "Urban Water Management Plan 2000," p. 4-1.

Future needs for M&I purposes are expected to increase nearly 40 percent over the next 20 years, to 84,791 AF. A large share of this can be attributed to growth in residential deliveries in the City of Santa Rosa, which anticipates an overall increase of approximately 50 percent over that time period.[30]

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25 U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: Sonoma County, California.

26 U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: California.

27 U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: Sonoma County, California.

28 U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: California.

29 Sonoma County Water Agency, "Urban Water Management Plan 2000," pp. 4-1 to 4-2.

30 Sonoma County Water Agency, "Urban Water Management Plan 2000," Table 4-2, p. 4-2.

3.1.3 AGRICULTURE AND WATER USE

The Central Coast region within which Sonoma County lies is home to some very fertile soils, allowing a wide range of agricultural products to be produced. The county's crop mix includes wine grapes, orchard crops, strawberries, and vegetables. The region also includes some of the highest value of farm products sold per farm.[31]

In 2001, Sonoma County ranked 16th among the 58 California counties for gross value of agricultural production. Approximately 54 percent of the county's total acreage is devoted to agricultural production.[32] Commodity groups grown include field crops, vegetable crops, fruit and nut crops, nursery, flowers and foliage crops, apiary, and livestock and livestock products. Sonoma County ranks second in the state for production of all types of grapes, producing 11.6 percent of California's total gross production value of the crop.[33] Shares of production value by commodity group for Sonoma County in 2001 are shown in Table 3-5.

Table 3-5 2001 Sonoma County Agricultural Production Value Shares

Fruit and Nut Crops	65.2%
Livestock and Poultry Products	17.1%
Livestock and Poultry	9.5%
Nursery Products	5.1%
Vegetable Crops	1.7%
Field Crops	1.3%

Source: California Agricultural Statistics Service, August 2002. Summary of County Agricultural Commissioners' Reports, 2001.

The most recent statistics available from the Sonoma County Wineries Association are for 1999. The data show the following economic influence of the various segments of the wine industry in Sonoma County.

- 4,263 individuals employed by wineries with a gross payroll of $142 million.
- 3,004 individuals employed by vineyards, with gross payroll of $54 million.
- 2 million tourists to wineries, with an estimated $201 million in expenditures.

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31 California Farm Bureau Federation, "Facts and Stats about California Agriculture," 2003, http://www.cfbf.com/info/agfacts.aspx, accessed May 1, 2003.

32 Pesconi, Tim, "County's ag goods known for quality," *Press Democrat,* June 9, 1996, www.pressdemo.com/outlook/.

33 California Agricultural Statistics Service, August 2002, *Summary of County Agricultural Commissioners' Reports, 2001*.

In 1997, there were 570,804 total acres of land in farms, with an average size of 208 acres per farm. Of that acreage, 80,771 acres were harvested cropland and 49,261 of those acres, or 61 percent, were irrigated.[34] The market value of all agricultural products sold was $463.6 million, $320.3 million of which came from crops (including nursery and greenhouse crops). Hay and alfalfa comprised 26,565 acres, producing 65,715 dry tons. There were 2,001 acres of harvested vegetables, and 50,301 acres in orchards.[35]

Table 3-6 shows the acreage, irrigated acreage, and production value (in dollars) of Sonoma County by crop for years 2000 and 2001. Total irrigated acreage is currently slightly greater than 63,000 acres, with total production value just under $400 million. Wine grapes continues to be the largest crop in the county by all three of these measures, followed by field crops, and apples. Further, despite the reduction in total production value from 2000 to 2001, the total and irrigated acreage has increased, with irrigated acreage staying at approximately 73 percent of total harvested acreage.[36]

The Russian River basin includes several hydrologic basins or subunits. Each subunit is a relatively distinct geographic area of uniform hydrologic condition. Several irrigation districts and water agencies divert water from the Russian River system. In Sonoma County, SCWA serves the Middle Russian River subunit. The source of irrigation water for each of the irrigation districts and water agencies varies. SCWA pumps from various individual diversion points along the Russian River in the Middle Russian River area.

3.1.4 Recreation

Sonoma County is well known for its vineyards, the Middle and Lower Russian River recreation areas, and large tracts of coastal redwoods. The Russian River flows slowly in the summer through the redwoods in the Middle and Lower reaches, close to well-known vineyards, making this a popular tourist destination. Recreation and tourism generate significant economic activity within the Russian River basin in Sonoma County. The California Department of Tourism estimated 2001 visitor spending at $952.7 million in Sonoma County. Of this, it was estimated that $194.6 million was spent directly on recreation-related activities.[37]

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[34] U.S. Department of Agriculture, National Agricultural Statistics Service, *1997 Census of Agriculture,* March 1999.

[35] Ibid.

[36] Sonoma County Agricultural Commissioners, *Sonoma County Agricultural Crop Report, 2001.*

[37] Dean Runyan Associates, “Travel Impacts for Selected Counties,” from *California Travel Impacts by County, 1992-2001, 2002 Preliminary State Estimates*, February 26, 2003.

Table 3-6 Sonoma County Crop Acreage and Production Value

Crop	Year	Acreage	Irrigated Acreage 2/	Production Value	
Fruit and Nuts					
Wine Grapes	2001	58,364	46,691	$	374,389,700
	2000	55,877	44,702	$	389,853,900
Apples	2001	2,952	2,324	$	5,905,400
	2000	3,786	2,981	$	2,764,500
Prunes	2001	227	179	$	158,600
	2000	297	234	$	229,100
Walnuts	2001	190	150	$	50,700
	2000	211	166	$	57,200
Miscellaneous and Other Fruits and Nuts 1/	2001	209	165	$	434,100
	2000	175	138	$	469,200
Vegetables	2001	438	438	$	10,119,500
	2000	659	659	$	12,140,600
Field Crops					
Oat Hay	2001	7,806	1,952	$	1,305,800
	2000	5,986	1,497	$	1,183,700
Oat Silage	2001	5,197	1,299	$	1,912,700
	2000	4,251	1,063	$	1,490,700
Other hay and silage	2001	2,295	574	$	780,200
	2000	2,802	701	$	805,600
Irrigated Pasture	2001	9,450	9,450	$	945,000
	2000	9,550	9,550	$	955,000
Total	**2001**	**87,128**	**63,221**	**$**	**396,001,700**
	2000	**83,594**	**61,689**	**$**	**409,949,500**

Source: Sonoma County Agricultural Commissioners, *Sonoma County Agricultural Crop Report, 2001.*

[1] Includes bushberries, kiwi, black walnuts, plums, all pears, peaches, strawberries, figs, chestnuts, olives, etc.

[2] Irrigated acreage was estimated based on the share of irrigated acreage to total harvested acreage by crop type in the 1997 Agricultural Census and applied to the total 2000 and 2001 harvested acreage by crop type in the annual agricultural crop reports put out by the Sonoma County Agricultural Commissioners Office. Recreation.

The Russian River in Sonoma County is well-developed for recreation. The river flows south from the border of Mendocino County, through the city of Cloverdale and then through a relatively undeveloped stretch until it reaches Healdsburg. Most recreation development on the river is from this point south of Healdsburg and then west at Mirabel Park near Forestville to the Pacific Ocean at Jenner.

Many businesses located on the Russian River offer kayaking, canoeing, other watercraft use, and tubing rentals for day and overnight use. Five regional parks provide public access to the Russian River for swimming, paddling, and floating the Russian, hiking trails, and day use facilities. Three state parks are located in Sonoma County in the Russian River area. Willow Creek State Environmental Learning Camp is the only state park located directly on the Russian River, and offers a small number of primitive camp sites and access to both the river and an ocean beach. The Armstrong Redwoods State Reserve and Austin Creek State Recreation Area complex is located approximately 3 miles from the Russian River and offers camping, hiking, and day use activities.[38] Private beaches and campgrounds round out the facilities with access to the river.

Recreational users include the local residents of Sonoma County and a large number of recreational users residing outside of these counties. Many of the visitors from outside the area reside in the San Francisco Bay and North Bay areas. People who utilize the Russian River and the lake regularly participate in other tourism-related activities, such as wine tasting, while visiting the area.

3.1.4.1 Lake Sonoma

USACE manages the natural and man-made resources surrounding Lake Sonoma. The Lake Sonoma recreation area is divided into six distinct areas:

- Warm Springs Dam Recreation Area: Located downstream of the dam, this area occupies the largest piece of relatively flat land within the project boundaries. The day use area includes 12 acres of lawn, individual and group picnic areas, parking, and a visitors center. Nearby are Dry Creek and the Don Clausen Fish Hatchery.

- Project Overlook Area: Located off Stewarts Point Road at the eastern edge of the lake, this area includes a parking lot and restrooms serving an arbor-covered viewing plaza and tower.

- Lake Sonoma Marina: Located south of the overlook, the concessionaire-operated marina is reached by an access road from Stewarts Point Road. The marina has individual and group picnic areas, restrooms, a boat ramp, boat slips, boat rentals, a fueling station, and store.

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[38] California State Parks Department, "California State Parks, Armstrong Redwoods State Preserve," 2000, website: http://www.parks.ca.gov/default.asp?page_id=450, accessed June 11, 2003.

- Public Boat Ramp: Located west of the Warm Springs bridge, this area consists of a large parking area and a multilane boat ramp.

- Liberty Glen Campground: Located south of Rockpile Road on the northeast fork of the lake, this area consists of restrooms, hot showers, a trailer dump station, 113 individual campsites, and two camp areas for recreational vehicles and tent campers.

- Yorty Creek Recreation Area: Located south of Rockpile Road on the northeast fork of the lake, this area consists of a car-top boat launch facility, parking lot, swimming beach, picnic area, and restrooms.

In addition to these recreation areas, Lake Sonoma has 40 miles of developed horseback and hiking trails and a number of boat-in campsites. There is also an 8,000-acre Wildlife Management area jointly managed by the USACE and CDFG.

Visitation records have been kept for Lake Sonoma since 1979 when the park was under construction. Until 1986, visitation at Lake Sonoma was recorded by vehicle estimation. In 1986, magnetic vehicle counters were installed and visitor use surveys conducted. Visitation has increased steadily since completion of Warm Springs Dam, but has remained relatively constant since 1992, with approximately 526,000 visits per year.[39] Visitation by year is shown in Table 3-7.

Most visits to Lake Sonoma occur between Memorial Day and Labor Day. The months of June, July, and August account for 45.0 percent of all visitation; September, October, and November account for 17.6 percent; December, January, and February account for 12.2 percent; and March, April, and May account for 28.4 percent (see Table 3-8). Approximately 47 percent of the visitors to Lake Sonoma live within 25 miles of Lake Sonoma; another 31 percent live within 26 and 100 miles of the project, and the remaining 22 percent live more than 100 miles from Lake Sonoma.[40]

Approximately 88 percent of the visits to Lake Sonoma are for day use, and the remaining 12 percent are overnight campers. Day use and camping visitors participate in picnicking (12 percent), boating (34 percent), water-skiing (21 percent), fishing (15 percent), swimming (21 percent), hunting (0.5 percent), and sightseeing (49 percent).[41]

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[39] U.S. Army Corps of Engineers, Operational Management Plan: Lake Sonoma, 1997.

[40] Ibid.

[41] Ibid.

Table 3-7 Lake Sonoma Visitation, by Month (1996 to 2002)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
1986	23,116	24,850	34,096	53,745	76,283	86,685	97,087	76,861	41,609	26,007	20,804	16,759	577,902
1987	23,536	25,301	34,716	54,721	77,669	88,260	98,851	78,257	42,365	26,478	21,182	17,064	588,400
1988	21,240	22,833	31,329	49,383	70,092	79,650	89,208	70,623	38,232	23,895	19,116	15,399	531,000
1989	22,776	24,484	33,595	52,954	75,161	85,410	95,659	75,730	40,997	25,623	20,498	16,513	569,400
1990	22,340	24,016	32,952	51,941	73,722	83,775	93,828	74,281	40,212	25,133	20,106	16,197	558,503
1991	24,460	26,295	36,079	56,870	80,718	91,725	102,732	81,330	44,028	27,518	22,014	17,734	611,503
1992	20,560	22,102	30,326	47,802	67,848	77,100	86,352	68,362	37,008	23,130	18,504	14,906	514,000
1993	18,300	22,500	30,300	46,500	51,500	76,900	102,700	74,200	42,800	18,300	16,000	21,600	521,600
1994	18,200	23,200	34,700	42,100	59,700	73,500	95,964	59,100	44,200	27,500	23,800	22,800	524,764
1995	42,278	18,375	42,055	47,366	72,024	83,755	98,182	84,098	53,910	37,758	32,288	19,962	632,051
1996	32,023	32,417	40,264	51,139	67,546	81,991	95,021	34,623	43,536	34,244	30,091	23,836	566,731
1997*													482,000
1998*													446,900
1999*													362,162
2000*										22,421	29,388	14,782	
2001	12,633	12,125	32,749	33,478	59,432	51,444	48,653	48,798	42,783	30,319	21,428	14,615	408,457
2002	15,399	27,658	26,877	34,513	48,321	68,467	63,777	56,657	46,127				
Average	**22,835**	**23,550**	**33,849**	**47,886**	**67,694**	**79,128**	**89,847**	**67,917**	**42,908**	**26,794**	**22,709**	**17,859**	**526,358**

*Monthly data not available for 1997 through September 2000.

Sources: 1986 to 1996 data: U.S. Army Corps of Engineers. 1997. Operational Management Plan: Lake Sonoma.

2000 to 2001 data: Atchison, Michael, May 2, 2003, "Activity Distribution Reports, Lake Sonoma," and U.S. Army Corps of Engineers San Francisco District, Lake Sonoma/Warm Springs Dam, Geyserville, California.

Table 3-8 Lake Sonoma Average Visitation by Month and Monthly Percent of Total Average Yearly Visitation

Month	Average Visitation	Percentage of Yearly Average Total
January	22,835	4.34%
February	23,550	4.47%
March	33,849	6.43%
April	47,886	9.10%
May	67,694	12.86%
June	79,128	15.03%
July	89,847	17.07%
August	67,917	12.90%
September	42,908	8.15%
October	26,794	5.09%
November	22,709	4.31%
December	17,859	3.39%
Average Total Visitation	**526,358**	**100.00%**

Sources: 1986 to 1996 data: U.S. Army Corps of Engineers. 1997. Operational Management Plan: Lake Sonoma. 2000 to 2001 data: Atchison, Michael, May 2, 2003, "Activity Distribution Reports, Lake Sonoma," and U.S. Army Corps of Engineers San Francisco District, Lake Sonoma/Warm Springs Dam, Geyserville, California.

3.1.4.2 Canoeing and Other Paddle Sports

"Paddle sports" encompass canoeing, kayaking, and other watercraft use. Paddling, tubing, and swimming are popular on the Russian River, especially during the spring and summer. Paddling is most prominent in the area of the Russian River below Healdsburg.

3.1.4.3 Fishing

Fishing is common on the Russian River, Dry Creek, and in Lake Sonoma. The Russian River has runs of wild and hatchery-reared steelhead and this fishery is very popular from October through March when the fish return to spawn. Other summer fisheries on the river, Dry Creek, and in Lake Sonoma include shad, striped, largemouth, and smallmouth bass, and rainbow trout.

In 1997, California revised its steelhead sport fishing regulations to not allow any taking of wild steelhead.[42] Hatcheries marked fish by removing their adipose fins to enable fishermen to identify hatchery fish so that they could release the wild fish and keep the hatchery fish. Without the marking of hatchery fish, it is likely that steelhead fishing would be reduced. The hatchery-reared steelhead fishery on most of the mainstem of the

42 Jackson, Terry A., manager of California Department of Fish and Game, Fish and Watershed Branch, Report-Restoration Card program, Sacramento, California, personal communication, May 16, 2003.

Russian River is technically open year-round with a bag limit of two fish.[43] However, most steelhead fishing takes place in October through March, when the adults return to spawn.

One fishing guide roughly estimated that approximately 95 percent of the fishing trips he led are for steelhead. Of his clients, approximately 80 percent were not from the local area and stayed overnight in local accommodations.[44]

Summer fishing on the Russian and its tributaries starts with the shad run in May and continues through July. The smallmouth bass fishery becomes popular as the river and lake warms up. Lake Sonoma is very popular for lake fishing.[45] On Lake Sonoma, the fishery includes largemouth bass, rainbow trout, red-eared sunfish, channel catfish, and smallmouth bass. [46]

3.1.4.4 Boating

Lake Sonoma is popular for motorized boating, waterskiing, and personal watercraft use. Estimated total trips for these activities for fiscal year 2000 to 2001 at the lake were over 218,000, and in fiscal year 2001 to 2002 were almost 335,000. Other motorized boating occurs in the wider and deeper parts of the Russian River, most likely in conjunction with fishing. However, no statistics on motorized boating on the river are currently available.

3.1.5 Hydroelectric Power Generation

The proposed alteration in flows in the Upper Russian River and Dry Creek will affect hydroelectric generation at Warm Springs Dam. The hydroelectric generation facility at Warm Springs Dam on Lake Sonoma is owned and operated by the SCWA.

The turbines at Warm Springs Dam operate at flows between 75 and 180 cfs. When flows are below this range, the turbines do not operate, and above this range, excess water above the 180 cfs is spilled. The turbines generate 3 MW of electricity at peak capacity (180 cfs). Between January 1999 and May 2003, the turbines operated 92.5 percent of the time and generated over 14,500 MW of electricity per year, on average.[47]

All the power produced is sold to PG&E at a fixed contract rate that differs between summer and winter months. This contract became effective August 1, 2001, and extends

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43 State of California Fish and Game Commission, *2003 Freshwater Sport Fishing Regulations Booklet*, March 1, 2003, p. 48.

44 Swaney, Mike, owner of Fishing Guide Service by Bernard, Sebastopol, California, personal communication, May 23, 2003.

45 Cox, Bill, fisheries biologist for the California Department of Fish and Game, Sonoma County, California, personal communication, May 16, 2003.

46 Ibid.

47 All information and data regarding generation at Warm Springs Dam was obtained from discussions and SCADA system data provided by Pam Jeane, SCWA Deputy Chief Engineer of Operations, May 9 and 12, 2003; and from Randy Cullen, SCWA Operations Manager, May 13, 2003.

at least five years. The price paid is a composite of a capacity payment and an energy payment. The energy payment is targeted to be $47.18/MW during the summer (May 1 through October 31) and $60.33/MW during the winter, and adjustments are made so that actual payments are as close as possible to the target.

In addition, the monthly capacity payment is due whenever SCWA meets its minimum contract power requirements. The capacity payment is currently $7,922 during the winter and $29,083 during the summer.[48] Table 3-9 summarizes payments made over the last 19 months and demonstrates how billing is computed.

Table 3-9 Warm Springs Power Payment Summary

Month	KWH Generated	Payments Energy	Payments Capacity	Service Charge	Total Payment	Average Energy Pymt
Sep-01	1,098,887	$42,927	$29,057	$75	$72,059	
Oct-01	960,459	$45,697	$29,057	$75	$74,829	
Nov-01	775,058	$46,863	$7,915	$75	$54,853	
Dec-01	1,474,312	$89,181	$7,915	$75	$97,171	
Jan-02	1,930,193	$115,917	$7,915	$75	$123,758	
Feb-02	1,186,368	$72,104	$7,915	$75	$79,945	
Mar-02	1,339,789	$80,847	$7,915	$75	$88,688	
Apr-02	1,226,390	$74,412	$7,915	$75	$82,252	$60.43
May-02	1,033,783	$49,541	$29,057	$75	$78,524	
Jun-02	1,053,749	$50,825	$29,057	$75	$79,808	
Jul-02	1,279,748	$61,739	$29,057	$75	$90,721	
Aug-02	1,512,376	$72,880	$29,057	$75	$101,863	
Sep-02	1,230,278	$59,588	$29,083	$75	$88,596	
Oct-02	1,191,116	$57,508	$29,083	$75	$86,516	$48.22
Nov-02	1,201,518	$73,297	$7,922	$75	$81,144	
Dec-02	1,417,264	$86,512	$7,922	$75	$94,359	
Jan-03	1,649,050	$101,931	$7,922	$75	$109,778	
Feb-03	1,583,844	$96,872	$7,922	$75	$104,719	
Mar-03	1,602,077	$97,580	$7,922	$75	$105,428	$61.20
Totals	**24,746,259**	**$1,376,221**	**$319,614**	**1,425**	**1,695,010**	

48 "Long-Term Energy and Capacity Power Purchase Agreement between Sonoma County Water Agency and Pacific Gas and Electric Company," May 7, 1984; and "Amendment to the Purchase Power Agreement between the Sonoma County Water Agency and Pacific Gas and Electric Company," July 31, 2001.

3.2 ECONOMY OF MENDOCINO COUNTY

3.2.1 CURRENT ECONOMIC BASE

The base data for the IMPLAN model developed for Mendocino County are displayed in Table 3-10. Just under $4.1 billion in goods and services are produced within Mendocino County, and these local industries support nearly 50,000 jobs and earnings of over $1.4 billion. As in Sonoma County, manufacturing is the largest industry in terms of output, contributing just over $1 billion, or more than a quarter of the county's total industry output. The lumber and wood products area of manufacturing has experienced declines in recent years, but still plays an important role in the Mendocino County economy. The two largest manufacturing employers in the county are the Building Products Group of the Masonite Corporation, a paperboard mill in Ukiah with 400 employees, and Georgia Pacific West, a sawmill in Fort Bragg with 400 employees.[49]

Table 3-10 Mendocino County IMPLAN Model Base Data

Industry	Output *($millions)*	Income *($millions)*	Employment *(# of jobs)*
Agriculture, Forestry, and Fishing	$212.576	$106.156	5,213
Mining	$10.761	$2.203	39
Construction	$431.805	$139.050	3,635
Manufacturing	$1,040.709	$222.700	5,780
Transportation, Communication, and Public Utilities	$288.107	$60.390	1,367
Trade (Retail and Wholesale)	$483.497	$225.631	9,878
Finance, Insurance, and Real Estate	$559.167	$73.337	2,663
Services	$719.560	$345.148	14,027
Government	$301.973	$241.209	6,332
Other[1]	$6.660	$6.738	735
Total	**$4,054.814**	**$1,422.562**	**49,669**

[1] For this model, "other" consists primarily of domestic services (such as cleaning and maid services), as well as an "inventory valuation adjustment," used to estimate the value of goods removed from inventory that were produced in a previous time period at a different value.

Source: 2000 IMPLAN data from Minnesota IMPLAN Group, Inc., with modifications by NEA.

[49] Upstate California Economic Development Council, *Mendocino County, California, Statistical Profile*, http://www.upstatecalifornia.com/NorCal/Pdf/Mendocino.pdf, downloaded June 3, 2003.

The services sector dominates employment in the county, contributing a little over 28 percent of the total jobs in the county, or over 14,000 jobs. The largest county employer in the services sector is Productive People Employment Services, a labor resource service located in Ukiah and with nearly 300 employees.[50] Several area hospitals are also significant employers in the services sector, such as the Mendocino Coast Hospital in Fort Bragg with 224 employees, the Howard Frank R Memorial Hospital in Willits with 160 employees, and the Ukiah Adventist Hospital in Ukiah with 150 employees.[51] Trade, which includes retail and wholesale, is the second largest employer, with nearly 9,900 jobs or nearly 20 percent of the county total employment. Agriculture is also an important contributor to the county economy, providing more than 10 percent of the total county jobs, and is discussed in greater detail later in this section of the report.

3.2.1.1 Population

Age, race, and ethnic characteristics of the Mendocino County population from the 2000 Census are presented in Table 3-11. A total of 86,265 people lived within the county in 2000. The distribution among age groups shows some differences between the county and the state. Nearly 41 percent of the Mendocino County population is at least 45 years old compared to just 31 percent of the state population.[52]

The population is predominantly white, with nearly 81 percent of Mendocino County residents identified as white in the 2000 Census. The next largest group, accounting for nearly 9 percent of the county population, includes those who selected “some other race.” Several Indian rancherias and reservations have lands within Mendocino County, which likely explains the near 5 percent of the population identified as American Indian or Alaska Native. Because the 2000 Census allowed the selection of more than one race for each person, another 4 percent of the population selected “two or more races.”

Hispanic origin is tallied separately from race, as a person of Hispanic origin can be of any race. Just under 17 percent of the county’s population identified themselves as being of Hispanic origin in the 2000 Census, as compared to 32 percent of the state population.[53]

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[50] Ibid.

[51] Ibid.

[52] U.S. Census Bureau, Census 2000, *Table DP-1 Profile of General Demographic Characteristics: 2000,* Geographic Area: California.

[53] Ibid.

Table 3-11 Age, Race, and Ethnicity Characteristics of Mendocino County Population (2000)

Age, Race, and Ethnicity Characteristics	Number of People	Percentage of County Total
Age Group (Years)		
0 to 19 years	24,381	28.3%
20 to 34 years	14,315	16.6%
35 to 44 years	12,451	14.4%
45 to 54 years	14,600	16.9%
55 to 64 years	8,809	10.2%
65 years and over	11,709	13.6%
Race		
White	69,671	80.8
Black or African American	536	0.6
American Indian and Alaska Native	4,103	4.8
Asian	1,038	1.2
Native Hawaiian and Other Pacific Islander	126	0.1
Some Other Race	7,427	8.6
Two or More Races	3,364	3.9
Hispanic Origin		
Hispanic	14,213	16.5
Non-Hispanic	72,052	83.5
Total Population	**86,265**	**100%**

Note: Percentages may not appear to add to 100 due to rounding.

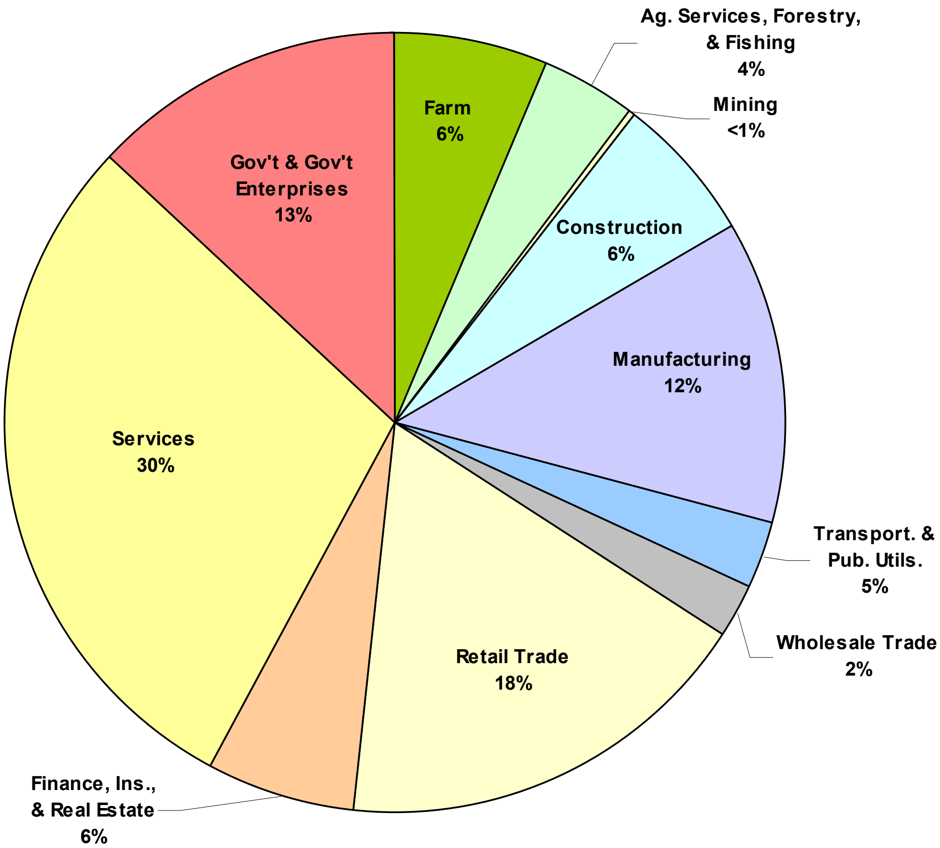
Source: U.S. Census Bureau, Census 2000, Table DP-1 Profile of General Demographic Characteristics: 2000, Geographic Area: Mendocino County, California.

In sharp contrast to Sonoma County, two-thirds of the residents of Mendocino County live in the unincorporated areas of the county, as shown in Table 3-12. The largest city in the county is Ukiah, with a population of 15,497, or 18 percent of the county's residents.

Table 3-12 Mendocino County Cities and Population (2000)

City	Number of People	Percentage of County Total
Fort Bragg	7,026	8%
Point Arena	474	1%
Ukiah	15,497	18%
Willits	5,073	6%
Incorporated	28,070	33%
Unincorporated	58,195	67%

Source: California Department of Finance, Revised Historical City, County, and State Population Estimates, 1991 to 2000, with 1990 and 2000 Census Counts, March 2002.



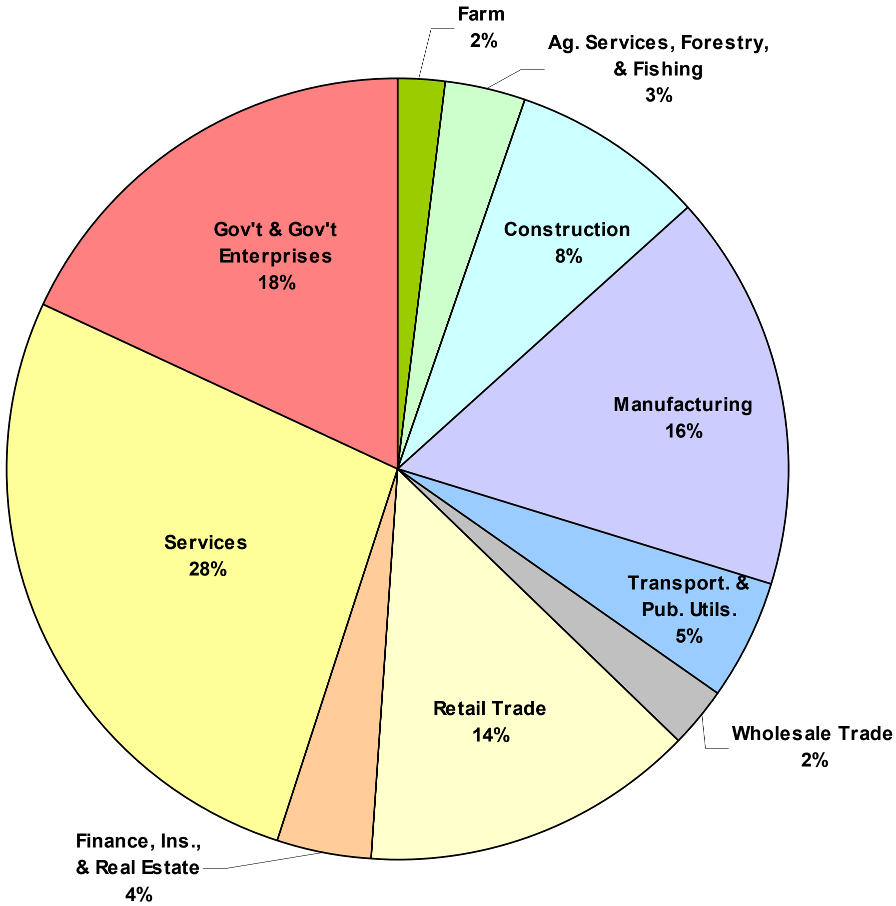
Source: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Economic Information System (REIS), 1969 to 2000*, CD-ROM, May 2002.

Figure 3-3 Mendocino County Employment by Industry (2000)

3.2.1.2 Employment and Earnings

REIS employment and earnings by industry data for Mendocino County are presented in Figures 3-3 and 3-4. The largest employer in Mendocino County is the services sector, which accounts for 30 percent of total employment. Other significant employers include retail trade with 18 percent of the jobs, government with 13 percent, and manufacturing with 12 percent. Agricultural employment in Mendocino County is also somewhat significant, with jobs on farms and in agricultural services, forestry, and fishing contributing approximately 10 percent of the county's total employment.

In terms of earnings, the services sector is also Mendocino County's largest, contributing 28 percent of total earnings, slightly less than its 30 percent share of total employment in the county. Retail trade contributes 14 percent of the total county earnings, somewhat less than its 18 percent share of total jobs. As in Sonoma County and elsewhere, the preponderance of part-time workers in the services and trade sectors, as well as the tendency for wages in these industries to be lower than others, likely affects the earnings figures. This is also true in the agricultural sectors, where even though farm and agricultural services jobs make up 10 percent of the county's total employment, earnings for these jobs only contribute 5 percent of total county earnings. Others sectors show greater earning power. While government accounted for just 13 percent of the jobs,



Source: U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Economic Information System (REIS), 1969 to 2000*, CD-ROM, May 2002.

Figure 3-4 Mendocino County Earnings by Industry (2000)

earnings in this industry contribute 18 percent of the county's total. Manufacturing shows a similar pattern, as 12 percent of the total jobs contribute 16 percent of total earnings.

The unemployment rate for the past several years has been somewhat greater in Mendocino County than for the total state of California, suggesting less opportunity for employment available in the county than for the entire state. In 2002, the annual average unemployment rate was 7.2 percent in Mendocino County,[54] compared to 6.7 percent for the state of California.[55] Unemployment in Mendocino County exhibits some seasonal characteristics, as it appears to reach its highest points in the winter months and lowest points in the summer months. For instance, in 2002, while the average unemployment rate for the year was 7.2 percent, the highest monthly rates were in January (9.8 percent) and February (9.2 percent) and the lowest monthly rates were in August and September

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[54] California Employment Development Department, Labor Market Information Division, "Civilian Labor Force, Employment, and Unemployment — Updated 5/7/2003," for Mendocino County.

[55] Ibid.

(5.5 percent for both).[56] Jobs in agricultural and timber-related industries are typically prone to this seasonality.

3.2.1.3 Economic Well-Being

The per capita income for Mendocino County in 2000 was $25,301, which was considerably lower than that of the state of California, at $32,363.[57] While Sonoma County ranked 10th of California's 58 counties in terms of per capita income, Mendocino County is ranked 24th.[58]

The most recent available poverty data are from the 2000 Census, and are based on income levels reported for 1999. In 1999, 2,402 families in Mendocino County were found to have incomes below the poverty level, representing 10.9 percent of all families in the county for which poverty status was determined.[59] This is a similar rate to that reported for the state of California, 10.6 percent.[60] When individual people are counted, 13,505, or 15.9 percent, of the Mendocino County residents for which poverty status was determined lived below the poverty level in 1999.[61] This is somewhat greater than the 14.2 percent of individuals living below the poverty level that was reported for the state in 1999.[62]

3.2.2 Agriculture and Water Use

Mendocino County is within the North Coast region, in which farms are generally larger in size per acre and smaller in number than other California regions. Hay, irrigated pasture, and rangeland covers privately owned land and leased public land. Wine grapes and pears are the principal crops produced in Mendocino County.[63] The agricultural areas of Mendocino County include Redwood Valley, Potter Valley, Ukiah Valley, Sanel Valley, McDowell Valley, Anderson Valley, Cole Ranch, Mendocino Ridge, and Yorkville Highlands.[64]

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[56] Ibid.

[57] U.S. Department of Commerce, Economics and Statistics Administration, Bureau of Economic Analysis, *Regional Economic Information System (REIS), 1969-2000*, CD-ROM, May 2002.

[58] Ibid.

[59] U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: Mendocino County, California.

[60] U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: California.

[61] U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: Mendocino County, California.

[62] U.S. Census Bureau, Census 2000, *Table DP-3, Profile of Selected Economic Characteristics: 2000*, Geographic Area: California.

[63] California Farm Bureau Federation, "Facts and Stats about California Agriculture," 2003, http://www.cfbf.com/info/agfacts.aspx, accessed May 1, 2003.

[64] Mendocino Wine Growers Alliance, "Quick Facts on Mendocino Wine Country," www.mendowine.com/wineries/facts.html, accessed May 23, 2003.

Mendocino County is second in California in timber production volume, with 117,596 million board feet in 2001. Timber was 28.5 percent of Mendocino County's total agricultural value. In 2001, Mendocino County ranked 32nd of the 58 California counties for gross value of agricultural production. Commodity groups grown include field crops, vegetable crops, fruit and nut crops, nursery, flowers, and foliage crops, and livestock and livestock products. The county ranks third in the state for pear production, based on gross production value.[65]

Table 3-13 shows the acreage, irrigated acreage, and production value (in dollars) of Mendocino County by crop for the year 2001. Total irrigated acreage is currently just under 25,000 acres, with total production value approximately $111 million. Wine grape production continues to be the dominant crop in the county by all three of these measures, followed most closely by pears in production value and by irrigated pasture in total and irrigated acres. Irrigated acreage comprises over 95 percent of the total harvested acreage, for which data are available.[66] It should be noted, however, that this percentage would decline with the addition of the miscellaneous field crop acreage, as the estimated percent irrigated is only 38 percentage. The magnitude of the percent decline depends on the actual total acreage of those crops.

Table 3-13 2001 Mendocino County Crop Acreage and Production Value

Crop	Total Acres	Irrigated Acres[6]	Production Value ($)
Apples	421	384	870,000
Wine Grapes	16,446	15,493	87,678,400
Pears	2,427	2,212	14,527,000
Walnuts	75	68	[4]
Miscellaneous Fruit/Nuts[1]	122	111	1,157,000
Vegetable Crops	360	360	1,111,500
Miscellaneous Field Crops[2]	N/A	N/A[3]	4,350,000
Irrigated Pasture	6,000	6,000	999,000
Total[5]	**25,851**	**24,628**	**$110,692,900**

1 Includes berries, cherries, chestnuts, guava, peaches, persimmons, pistachios, plumbs, olives, and table grapes.
2 Includes alfalfa, barley, beans, corn, oats, and hay.
3 Irrigated acres of miscellaneous field crops are assumed to equal approximately 38 percent of total acreage.
4 Production value is included in "Miscellaneous Fruit/Nuts" category.
5 Does not include acreage for miscellaneous field crops, as data are not available.
6 Irrigated acreage was estimated based on the share of irrigated acreage to total harvested acreage by crop type in the 1997 Agricultural Census and applied to the total 2001 harvested acreage by crop type in the annual agricultural crop report put out by the Mendocino County Agricultural Commissioners Office.

Source: County of Mendocino, Department of Agriculture, Mendocino County Crop Report, 2001.

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65 California Agricultural Statistics Service, *Summary of County Agricultural Commissioners' Reports, 2001*, August 2002.

66 County of Mendocino, Department of Agriculture, *Mendocino County Crop Report, 2001*.

In 1997, there were 638,566 total acres of land in farms, with an average size of 585 acres per farm.[67] Of that acreage, 30,425 acres were harvested cropland and 22,219 of those acres, or 73 percent, were irrigated. The market value of all agricultural products sold was $116.9 million, $102.5 million of which came from crops (including nursery and greenhouse crops). Hay and alfalfa comprised 10,062 acres, producing 21,914 dry tons. There were 556 acres of harvested vegetables, and 19,272 acres in orchards.[68]

Several irrigation districts and water agencies divert water from the Russian River system. In Mendocino County, these include the Potter Valley Irrigation District (PVID) located in the Coyote subunit, the Redwood Valley County Water District (RVCWD) located in the West Fork subunit, and the MCRRFCD located in the Upper Russian River subunit. The source of irrigation water for each of the irrigation districts and water agencies varies. PVID pumps water directly from the project tailrace. RVCWD pumps water from Lake Mendocino, and MCRRFCD has various individual diversion points along the Russian River in the Upper Russian River area.

3.2.3 Recreation

Recreation and tourism generate significant economic activity within the Russian River Basin in Mendocino County. The California Department of Tourism estimated 2001 visitor spending at $333.0 million in Mendocino County. Of this, it was estimated that $62.8 million in Mendocino County was spent directly on recreation related activities.[69]

3.2.3.1 Lake Mendocino

Lake Mendocino is located 2 miles northeast of Ukiah, off U.S. Highway 101 where the redwood forests meet the wine country. Created in 1958 by the construction of Coyote Valley Dam on the East Fork Russian River, the lake has a surface area of 1,822 acres.[70] In addition to providing flood protection, water storage, and hydroelectric power, the dam and lake provide many recreation opportunities.

The USACE manages the natural and man-made resources surrounding Lake Mendocino. Activities include fishing for striped bass, largemouth and smallmouth bass, bluegill, and several varieties of catfish. Sailing, boating, waterskiing, swimming, and picnicking are also popular. Facilities at the lake include campgrounds, RV pads, boat ramps, day use areas, and a marina. The Lake Mendocino recreation area is divided into six distinct recreation areas or management units:

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67 U.S. Department of Agriculture, National Agricultural Statistics Service, *1997 Census of Agriculture*, March 1999.

68 County of Mendocino, Department of Agriculture, *Mendocino County Crop Report, 2001*.

69 Dean Runyan Associates, "Travel Impacts for Selected Counties," from *California Travel Impacts by County, 1992-2001, 2002 Preliminary State Estimates*, February 26, 2003.

70 U.S. Army Corps of Engineers, Lake Mendocino, http://www.spn.usace.army.mil/projects/ormlakemendocino.html, accessed June 2003.

- Sho-da-kai: An island located near the dam, the site is primitive and contains no recreational development. It is used primarily for fishing and day use.

- Che-ka-ka: An area that contains the Park Office, Coyote Valley Dam, the City of Ukiah's hydroelectric power plant, a steelhead trout taking and imprint facility, a 24-unit campground, boat launching facilities, a day use area, and an overlook.

- Pomo: A day-use area located at the northwest corner of the lake consisting of approximately 4 acres of irrigated lawn, a visitor's center, seven group picnic sites, and a swimming beach.

- Kyen: An area located at the northern end of the lake that contains a 103-unit campground, marina, boat launching facilities, amphitheater, and day use area.

- Bu-shay: An area located at the northeast end of the lake that area is the most remote of the intensive use areas. It contains a 176-unit campground with three group use camping areas, an amphitheater, and a day use area.

- Miti: An area located on the eastern edge of the lake, Miti is the designated wildlife area that contains no major improvements except an 18-unit primitive campground accessible only by boat or foot.

Visitation records have been kept for Lake Mendocino since 1964, when 550,000 recreation days were reported.[71] Visitation, as measured by "visits," is defined as the entry of one person onto a Corps' project to engage in one or more recreation activities, and has averaged approximately 581,000 visits per year, ranging from a low of 513,000 to a high of 685,000 (see Table 3-14).

Most visits occur between Memorial Day and Labor Day, with the months of June, July, and August accounting for 40.3 percent of all visits (see Table 3-15). September, October, and November account for 18.9 percent; December, January, and February account for 13.0 percent; and, March, April, and May account for 27.9 percent.

Approximately 53 percent of the visitors to Lake Mendocino live within 25 miles of Lake Mendocino (i.e., within Mendocino County). Another 21 percent live within 26 and 100 miles of the project, while the remaining 26 percent live more than 100 miles from Lake Mendocino.[72] Approximately 83 percent of the visits to Lake Mendocino are for day use, and approximately 17 percent are for camping. Day use and camping visitors participate

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71 U.S. Army Corps of Engineers, Operational Management Plan: Lake Mendocino, 1997.

72 U.S. Army Corps of Engineers, Operational Management Plan: Lake Mendocino, 1997.

Table 3-14 Monthly Visitation to Lake Mendocino 1986 to 2002*

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual Total
1986	23,116	24,850	34,096	53,745	76,283	86,685	97,087	76,861	41,609	26,478	21,182	17,064	**579,056**
1987	23,536	25,301	34,716	54,721	77,669	88,260	98,851	78,257	42,365	23,895	19,116	15,399	**582,086**
1988	21,240	22,833	31,329	49,383	70,092	79,650	89,208	70,623	38,232	25,623	20,498	16,513	**535,224**
1989	22,776	24,484	33,595	52,954	75,161	85,410	95,659	75,730	40,997	25,133	20,106	16,197	**568,202**
1990	22,340	24,016	32,952	51,941	73,722	83,775	93,828	74,281	40,212	27,518	22,014	17,734	**564,333**
1991	24,460	26,295	36,079	56,870	80,718	91,725	102,732	81,330	44,028	23,130	18,504	14,906	**600,777**
1992	20,560	22,102	30,326	47,802	67,848	77,100	86,352	68,362	37,008	18,300	16,000	21,600	**513,360**
1993	18,300	22,500	30,300	46,500	51,500	76,900	102,700	74,200	42,800	27,500	23,800	22,800	**539,800**
1994	18,200	23,200	34,700	42,100	59,700	73,500	95,964	59,100	44,200	37,758	32,288	19,962	**540,672**
1995	42,278	18,375	42,055	47,366	72,024	83,755	98,182	84,098	53,910	34,244	30,091	23,836	**630,214**
1996	32,023	32,417	40,264	51,139	67,546	81,991	95,021	34,623	43,536	34,947	26,403	26,113	**566,023**
1997	38,102	34,773	42,763	50,565	51,723	74,261	87,953	57,434	103,303	93,094	22,967	28,471	**685,409**
1998	28,119	36,971	37,453	99,254	38,449	71,300	76,630	51,487	51,850	18,727	51,507	19,060	**580,807**
1999	29,227	37,053	37,987	101,063	39,117	72,309	77,842	51,991	52,362	19,648	52,416	19,355	**590,370**
2000	29,551	37,452	38,355	101,327	40,289	72,986	78,549	52,657	52,994	19,983	52,987	19,998	**597,128**
2001	29,481	37,598	39,485	101,994	40,857	73,564	79,457	54,108	53,518	20,650	53,106	20,384	**604,202**
2002	29,998	38,092	40,973	103,139	41,693	74,871	78,115	53,841	52,468	18,119	47,582	18,183	**597,074**

*Note: "Visit" defined as the entry of one person onto a Corps project to engage in one or more recreation activities.
Source: Leonard, Steve, June 1, 1998, and May 19, 2003, personal communications, Park Manager, U.S. Army Corps of Engineers Lake Mendocino, Ukiah, California.

Table 3-15 Average Monthly Visits to Lake Mendocino 1986 to 2002, and Percent of Average Total Yearly Visits

Month	Average Visits	Percent of Total
January	26,665	4.59%
February	28,724	4.95%
March	36,319	6.25%
April	65,404	11.26%
May	60,258	10.37%
June	79,297	13.65%
July	90,243	15.54%
August	64,646	11.13%
September	49,141	8.46%
October	29,103	5.01%
November	31,210	5.37%
December	19,857	3.42%
Yearly Total	**580,867**	**100.00%**

Source: Leonard, Steve, June 1, 1998, and May 19, 2003, personal communications, Park Manager, U.S. Army Corps of Engineers Lake Mendocino, Ukiah, California.

in picnicking (18 percent), boating (22 percent), water-skiing (13 percent), fishing from a boat (4 percent), fishing from shore (8 percent), swimming (35 percent), hunting (3 percent), and sightseeing (29 percent).[73]

3.2.3.2 Upper Russian River

On the Upper Russian River, from Ukiah to the Mendocino/Sonoma County line, there are limited developed public access facilities, although some canoeing occurs in the lower part of this area. No estimates are available for the number of recreationists using the Russian River in Mendocino County, so this reach was not considered further in this analysis.

3.2.4 HYDROELECTRIC POWER GENERATION

The City of Ukiah owns and operates the Lake Mendocino Hydroelectric Power Plant at Coyote Valley Dam. The power plant at Coyote Valley Dam was added onto the existing dam structure and completed in May 1986. The peak capacity is 3 MW at a flow of 400 cfs, and its minimum operating range is 125 cfs. The City of Ukiah was issued a 50-year license by the Federal Energy Regulatory Commission (FERC) in April 1982 to operate the facility through 2032. The turbine produced between 11,000 and 18,000 MW

[73] U.S. Army Corps of Engineers, Operational Management Plan: Lake Mendocino, 1997.

annually from 1987 to 1993, but from 1994 to 1996 the generator produced only 6,700 to 9,000 MW annually, and the generator shut down completely in 1997, due to a broken diversion gate on the penstock.[74]

The gate was recently repaired, but the City of Ukiah is awaiting a Biological Opinion by NOAA Fisheries of the hazard to fish populations before the generator can begin operations again. The diversion gate is not easily opened and closed, and the penstocks are only designed to handle flows of less than 2,000 cfs, so in the future when the dam is being operated for flood control during the winter months (October through March), releases will be diverted around the penstocks entirely. From April through September, the penstocks can handle the entire release flow.

Under normal circumstances, Coyote Valley Dam releases are determined by factors such as flood control, minimum streamflow requirements, and water supply, rather than by power generation. The power that is generated is not sold on the market, but instead offsets power obtained by the city from other sources. Out of a total baseload power demand of 32 MW for the City of Ukiah, the Coyote Valley Dam power plant could provide approximately 10 percent.

The City of Ukiah can meet all power demands in ordinary circumstances from its own generation at a blended (weighted average) cost of $65/MW. The city also has a firm contract for supplemental power with Calpine Energy for a blended rate of $65/MW. For the purposes of this analysis, a value of $65 for each MW produced was assumed, and total production between the various scenarios then compared. On average, the generator at Coyote Valley Dam produces 0.0075 MW of power for each cfs of flow and the generator operates 95 percent of the time.[75]

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74 All information and assumptions regarding Coyote Valley Dam operations and power generation was obtained from discussions with Daryll Barnes, Director of Public Utilities for City of Ukiah, May 14 and 21, 2003.

75 All information and assumptions regarding Coyote Valley Dam operations and power generation was obtained from discussions with Daryll Barnes, Director of Public Utilities for City of Ukiah, May 14 and 21, 2003

4.1 RECREATION

4.1.1 IMPACTS OF FLOWS AND LAKE LEVELS ON RECREATION

Recreational activities relying on Lake Sonoma are partially dependent on reservoir levels, and paddling activities on the Russian River and Dry Creek are partially dependent on flow conditions. Consequently, alterations in storage levels of and releases from Lake Mendocino and Lake Sonoma may impact the recreational opportunities provided by the lakes, the Russian River, and Dry Creek.

Impacts on recreation activities were measured for Lake Sonoma, Lake Mendocino, the Cloverdale to Healdsburg reach of the Russian River, and the Healdsburg to ocean reach of the Russian River (reported elsewhere) for the prime recreational season of May through September.

For Lake Sonoma, Lake Mendocino, and the Cloverdale to Healdsburg river reach, four flow phases or scenarios were analyzed in the *Russian River Biological Assessment* (Section 5.3, Water and Estuary Management, and Appendix A)[76]; the D1610-Current, FP-Current, FP-75% and FP- Buildout. Each of these phases were analyzed under the *all* water supply condition and this condition was examined at three exceedance levels; 10 percent, 50 percent, and 90 percent. The *all* water supply condition includes all of the types of water years of record experienced in the basin. The *all* water supply condition at 50 percent exceedance can be considered to be the "average" condition.

4.1.2 LAKE SONOMA

At the 50 percent exceedance level, no low-water thresholds were violated for any of the four scenarios. Under both the baseline and flow scenario projections of lake levels, there would always be enough water in the reservoir to provide lake levels high enough for those activities that would be affected by low lake levels. This conclusion also holds at the 90 percent exceedance level reflecting drier than average conditions.

The high water-level threshold was exceeded in May at the 50 percent exceedance level for the baseline and all three phases of the flow proposal. Because the lake was at essentially the same level for the baseline and the scenarios, this reflects no change from the baseline and thus is not an impact resulting from the scenarios.

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[76] Ibid.

4.1.3 LAKE MENDOCINO

At the 50 percent exceedance level, no high- or low-water threshold was violated, reflecting no change from the baseline for the flow proposal and thus no impact from the flow proposal.

4.1.4 RUSSIAN RIVER

4.1.4.1 Cloverdale to Healdsburg Reach

Table 4-1 shows the flows by month for the *all* water supply condition at 50 percent exceedance. The shaded cells in the table indicate in which months the flows fell below the 140 cfs threshold. None of the flows fell below the threshold for the baseline D1610 Current. Two of the scenarios had monthly values that fell below the threshold, indicating that conditions for canoeing and other watercraft use will be less favorable under the flow scenarios than they are in the baseline.

Table 4-1 Flow Levels by Month, and Thresholds that Affect Canoeing

***All* Water Supply Condition** **50% Exceedance** **Daily average flow exceedance (cfs)**					
Flow Scenario	**May**	**June**	**July**	**August**	**September**
D1610-Current	365	232	234	209	167
FP-Current	361	183	171	111	94
FP-75%	353	193	207	156	135
FP- Buildout	357	211	210	157	149

4.1.4.2 Healdsburg to Ocean Reach

Changes in river flows have a substantial effect on the recreation boating for this reach. With a baseline of 14,732 canoe days for the peak recreation season (May through October), under the scenarios this would be reduced by 10,035 visits.[77] Details about how reductions in canoeing use were estimated are found in Appendix D, Section D.3.3.1.

4.1.4.3 Direct Impacts to River Recreation

For purposes of determining direct economic impacts, paddler visits for river recreation were segmented into groups. Through the course of the peak recreation season, it was assumed that half the paddlers were associated with commercial enterprises, either through canoe rentals or guide services or both, and half were private parties that did not involve canoe rentals. In addition, it was further assumed that 20 percent of paddlers were

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77 ENTRIX, Inc., "Preliminary Recreation Assessment for the Flow Proposal," Appendix D, *Russian River Biological Assessment*, September 29, 2004.

considered day-use visitors, and the remaining 80 percent were overnight visitors.[78] Finally, a worst-case assumption was applied in estimating the impacts by assuming that watercraft users would not continue to use the river and that all expenditures from these activities would be lost. In other words, watercraft users' sole purpose in coming to the area is for watercraft use.

Expenditure pattern data for recreation visitors were examined from the literature. However, expenditure pattern data for paddlers are very limited or not applicable. Information was used from study on river recreation on the Rogue River in Oregon.[79] This information was formulated into expenditure patterns by visitor type (commercial or private, day-use or overnight) and per visit into sectors of the IMPLAN model. These expenditures are provided in Table 4-2. Per-visit expenditures are greatest at nearly $75 for overnight visitors using commercial canoeing services. Private day-use visitors still account for approximately $12 per day in expenditures.

Table 4-2 Assumed Expenditure Patterns per Visitor, by Type and Associated IMPLAN Sector (in 2000 dollars)

IMPLAN	Sector	Commercial Overnight	Commercial Day Use	Private Overnight	Private Day Use
433	Railroads	$0.04	$0.01	$0.04	$0.01
435	Motor Freight	$0.12	$0.05	$0.12	$0.05
447	Wholesale Trade	$1.72	$0.77	$1.72	$0.77
450	Food Stores	$0.74	$0.20	$0.74	$0.20
451	Service Stations	$1.30	$0.55	$1.30	$0.55
454	Eating & Drinking	$13.33	$6.84	$13.33	$6.84
455	Misc. Retail	$1.78	$1.22	$1.78	$1.22
463	Lodging	$18.75	$0.00	$18.75	$0.00
488	Amusement & Rec. Services	$36.82	$36.82	$2.45	$2.45
	Total	**$74.59**	**$46.46**	**$40.23**	**$12.09**

4.2 AGRICULTURE

Under current conditions, it is assumed that there will be no impacts to agricultural water users in Sonoma and Mendocino counties under the flow proposal. The analysis assumes that all current agricultural water users who divert water from the Russian River will continue to do so, so neither crop yield nor harvested acreage is impacted. The same

[78] ENTRIX, Inc., "Preliminary Recreation Assessment for the Flow Proposal," Appendix D, Attachment 6, *Russian River Biological Assessment*, September 29, 2004.

[79] Economic Strategies Northwest, "Economic Effects Study: Hellgate Recreation Area Management Plan, Report 1," prepared for the Bureau of Land Management, Medford District, Oregon, March 3, 1993.

holds true for the "full buildout" scenario: no impact to agricultural water users in Sonoma or Mendocino counties is assumed in this analysis.

4.3 HYDROELECTRIC POWER GENERATION

4.3.1 LAKE SONOMA RESULTS

Existing and proposed water management scenarios were analyzed: the baseline D1610 under current conditions (D1610-Current), the three phases of the flow proposal, flow proposal with no measures under current conditions (FP-Current), the flow proposal with no measures at 75 percent buildout (FP-75%) and the flow proposal with measures at buildout (FP-Buildout). Each of these scenarios were analyzed under *dry* supply conditions and *all* water supply conditions, and each condition was examined at three exceedance levels; 10 percent, 50 percent, and 90 percent. The *all* water supply condition includes all of the types of water years of record experienced in the basin. The *dry* water supply condition reflects those years when the January water levels in Lake Mendocino were such that special water management rules were used. In this sense, the *all* water supply condition at 50 percent exceedance can be considered average conditions. The results of the analysis for the *all* water supply condition at 50 percent exceedance are displayed in Table 4-3.

Table 4-3 Annual Revenue for the *All* Water Supply Condition at 50 Percent Exceedance — Lake Sonoma

Flow Scenario	Total Annual Revenue ($)	Percent Base (%)
D1610-Current	$951,000	
FP-Current	$664,000	69.8%
FP-75%	$752,000	79.1%
FP- Buildout	$664,000	69.8%

Under these conditions, power revenues can be expected to decline from 20 to 30 percent for the scenarios compared to what might be expected under the current conditions baseline.

The impacts of these reduced hydroelectric power revenues will be felt by SCWA, which relies upon these revenues along with charges to water contractors to pay for water delivery services. The total budget for water delivery services is approximately $22 million per year. If power revenues are reduced, a policy decision is required from the Board of Directors as to whether to absorb the decrease in terms of reduced services, or to increase rates to the water contractors to offset the loss.[80]

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[80] Pam Jeane, Deputy Chief Engineer, Sonoma County Water Agency, personal communication, May 12, 2003.

4.3.2 LAKE MENDOCINO RESULTS

As mentioned above, four scenarios were analyzed. Each of these scenarios were analyzed under *dry* supply conditions and *all* water supply conditions, and each condition was examined at three exceedance levels: 10 percent, 50 percent, and 90 percent. The *all* water supply condition includes all of the types of water years of record experienced in the basin. The *dry* water supply condition reflects those years when the January water levels in Lake Mendocino were such that special water management rules were used. In this sense, the *all* water supply condition at 50 percent exceedance can be considered average conditions. The results of the analysis for the *all* water supply condition at 50 percent exceedance are displayed in Table 4-4.

Table 4-4 Annual Revenue for the *All* Water Supply Condition at 50 Percent Exceedance — Lake Mendocino

Flow Scenario	Total Annual Revenue ($)	Percent Base (%)
D1610-Current	$1,181,000	
FP-Current	$1,064,000	90.1%
FP-75%	$1,081,000	91.6%
FP-Buildout	$1,087,000	92.1%

Under these conditions, power revenues can be expected to decline approximately 10 percent for the scenarios compared to what might be expected under the current baseline conditions.

4.4 REGIONAL IMPACTS

Changes in river flows have a substantial effect on the recreational boating for the Lower Reach of the Russian River. When this is translated into economic effects, this results in an estimated loss of 18 jobs, over $340 thousand dollars in total income, and over $830 thousand dollars in total output to the economy. Although this represents only a small portion of the totals for these factors in the total county economy, this may represent a substantial reduction for those businesses directly involved in providing services to these recreationists. This analysis did not consider potential positive impacts associated with increased water supply. Table 4-5 presents the analysis results for Sonoma County under the *all* water supply condition.

Table 4-5 Sonoma County Impacts — *All* Water Year Analysis

Industry	Output		Income		Employment	
	Direct	Total	Direct	Total	Direct	Total
Agriculture, Forestry, & Fishing	$0	$3,613	$0	$1,684	0.0	0.1
Mining	$0	$1,023	$0	$188	0.0	0.0
Construction	$0	$10,795	$0	$6,732	0.0	0.1
Manufacturing	$0	$18,139	$0	$5,116	0.0	0.1
Transportation, Communication, & Public Utilities	$1,404	$31,182	$523	$9,246		0.2
Trade (Retail & Wholesale)	$170,660	$219,095	$71,314	$93,159	3.7	4.5
Finance, Insurance, & Real Estate	$0	$76,000	$0	$15,083	0.0	0.4
Services	$347,576	$466,371	$141,834	$205,505	10.6	12.5
Government	$0	$7,367	$0	$3,430	0.0	0.1
Other[1]	$0	$520	$0	$516	0.0	0.0
Total	**$519,640**	**$834,106**	**$213,672**	**$340,659**	**14.3**	**18.0**

[1] For this model, "other" consists primarily of domestic services (such as cleaning and maid services), as well as an "inventory valuation adjustment," used to estimate the value of goods removed from inventory that were produced in a previous time period at a different value.

Note: Totals may appear not to add precisely due to rounding.

This study provided an examination of the economic implications of changes to project operations and potential flow scenarios evaluated in the 2004 *Russian River Biological Assessment*.[81] The scope of the analysis included Sonoma and Mendocino counties in California. Economic effects were measured for reservoir (Lake Sonoma and Lake Mendocino) and river-based (Russian River) recreation, energy production at affected hydroelectric generating facilities, and regional impacts in both Sonoma and Mendocino counties. It was confirmed that agricultural irrigation would not be affected by any of the flow scenarios.

The largest impacts stem from low flows during the recreation season in the Healdsburg-to-Ocean reach of the Russian River. Visits to the river for canoeing, other watercraft use, and kayaking would be reduced by over 10,000 visits, with the economic impact on Sonoma County of a reduction of approximately 18 jobs, an income reduction of over $340 thousand, and an output reduction of over $800 thousand. When viewed from the perspective of the total size of the Sonoma County economy, this is a small reduction in overall economic activity. When viewed from the perspective of those businesses depending upon adequate river flows for their float rental businesses, this may be considered a substantial reduction.

For the Cloverdale-to-Healdsburg reach of the Russian River, low flows can be expected to affect canoeing, other watercraft use, and kayaking during August and September under the FP-Current phase and during September for the FP-75% and FP-Buildout phases. Although the quantity of impact was not measured explicitly, some impact can be noted to the same or comparable businesses that are dependent upon river flows for their paddler rental services.

The impacts to reservoir recreation are expected to be negligible on both Lake Sonoma and Lake Mendocino. Reservoir levels would not be likely to change significantly, or could be slightly higher, under any water condition. The threshold high-water levels for facilities prompting temporary closure would rarely be violated at either lake under any of the scenarios. To the extent that higher water levels can be associated with greater recreation visitation, the scenarios could actually lead to increased recreation at these facilities. However, this link (water levels and recreation visits) has not been directly established in this study.

Under each of the phases of the flow proposal, hydroelectric energy production would be reduced. The value of power output from the project at Lake Sonoma could be reduced by 20 to 30 percent. This reduction in revenues would likely cause an increase in rates for water contractors.

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81 ENTRIX, Inc., *Russian River Biological Assessment*, prepared USACE and SCWA, September 29, 2004.

The reduction from Lake Mendocino is smaller, approximately 10 percent of that potential power generation under a D1610 regime. The difference in power generation is smaller at Lake Mendocino because the facility’s structural limitations require that it be shut down when flows are above 2,000 cfs. Thus, its power generating capability is limited under any condition.

ATTACHMENT 1

IMPLAN METHODOLOGY

METHODOLOGY FOR IMPACT ANALYSIS

To estimate the economic impacts resulting from wind-power development in the case study regions, I-O models were developed for each of the regions. These models are used to measure the indirect effects of project development on the regional economy, in terms of additional industry output, employment, and income. The model is based on IMPLAN ("IMpact analysis for PLANning"), a system of software and data used to perform economic impact analysis. Originally developed by the USDA Forest Service, the system is now maintained and marketed by the Minnesota IMPLAN Group, Inc. (MIG). The data are developed by MIG annually, using data collected at the national, state, and county level for all possible elements from a variety of state and federal sources. The models developed for this study were based on 2000 data, the most recently available at the outset of the study.

IMPLAN is a "nonsurvey" or secondary I-O system, as it does not require primary, survey-based data. It is based on national average technical relationships among industries to which information has been added on regional economic activity. The software allows for national-average conditions to be adjusted to account for unique regional conditions. IMPLAN is a popular tool to analyze regional impacts of policy changes because of the ease with which specific regional or local information can be incorporated into a model. While such information generally is from secondary sources, primary data, if available, can be incorporated as easily.

Changes to the data are commonly made in order to "fine-tune" the model, so that it accurately reflects the region's unique economy. The IMPLAN data were compared with published sources to identify any discrepancies and make corrections. Employment and earnings were compared to Regional Economic Information System (REIS, from the U.S. Department of Commerce) data, as well as individual state employment and earnings data. In most cases, the IMPLAN data were fairly consistent with the other data sources, so few adjustments were made.

The regional purchase coefficients (RPCs), which indicate the portion of locally produced goods and services used to meet local demand, were also evaluated. RPCs are by definition always positive and never larger than one. The supply/demand pool ratio, the ratio of local supply of a commodity to local demand, also serves as an upper limit for the RPCs. The appropriateness of the RPC for a commodity is evaluated based on a number of factors, including the size of the economy and number of economic linkages within the economy, as well as the nature of the commodity itself. Commodities are defined as bundles of goods, and in some cases, this bundle of goods is small (e.g., for Sector 1, dairy farm products, the primary commodity is raw milk, with some livestock sales), while for others the bundle of goods is large (e.g., for Sector 315, screw machine products and bolts, a large number of different commodities are produced). For commodities where the bundle of goods is large, it is more important to know specifically which good(s) are being produced locally, and how much is likely to be used to meet local demand. Adjustment to the RPCs were made based on local trading patterns, determined by identifying the manufacturers of certain goods within the county, knowledge of local conditions, and other data sources.

The IMPLAN models for each of the case-study regions were used to estimate the effects on the rest of the local economy of spending related to the construction and operation and maintenance of the wind-power developments. Because the businesses within a local economy are linked together through the purchase and sales patterns of goods and services produced in the local area, an action which has a direct impact on one or more local industries is likely to have an indirect impact on many other businesses in the region. For example, a decline in the production of wheat will lead to a reduction in spending in the local area as farms reduce production. Firms providing production inputs and support services to the farms would see a decline in their industry outputs as the demand for their products also declines. These additional effects are known as the indirect economic impacts. As household income is affected by the reductions in regional economic activity, additional impacts occur. The additional effects generated by reduced household spending are known as induced economic impacts.

A key element of an I-O model is the measurement of the direct, indirect, and induced linkages within a regional economy. The tool most often used to measure these interrelationships is known as a multiplier. A variety of multipliers are generated by an I-O model and each is associated with a specific industry. A multiplier is a single number which quantifies the total economic effects (for all businesses) which arise from direct changes in the economic activity of a single industry. Multipliers can be generated to measure the total output, income, and employment effects associated with changes in the demand for regional goods and services. For example, an output multiplier of 2.5 for the wheat industry would indicate that a $100,000 decline in sales by this industry would lead to an overall decline of $250,000 in business sales throughout the economy, including the initial $100,000 loss to the wheat sector. An employment multiplier of 2.0 for the railroad industry would indicate that a loss of ten jobs in this sector would lead to an additional loss of ten jobs in other industries for a total loss of 20 jobs throughout the regional economy.

The IMPLAN models are margined models. That is, the purchase of a commodity such as milk by a household in a grocery store is divided into components reflecting the retail, wholesale, transportation, and insurance margins, as well as the price to the producer, the milk processing industry. Separating out these margins is an important part of estimating the direct effect. For example, if only the grocery sector part of the total cost to the households is located in the impact area (the wholesale, transportation, insurance, and milk processing sectors are not present), then only the retail margin component of the total cost to the household can be counted as a direct effect.

For more information on IMPLAN software and databases, please see the User's Guide, Analysis Guide, and Data Guide, available from MIG, Inc. These three books are compiled into the manual, *IMPLAN Professional™ Version 2.0 Social Accounting and Impact Analysis Software.* This provides a good overview of the software, its applications, and database development and sources.

LIMITATIONS OF THE METHODOLOGY

IMPLAN analysis has some limitations which are attributable to the I-O methodology. One of the most important is that of fixed proportions: for any good or service, all inputs are combined in fixed proportions that are invariant with the level of output. Thus, there is no substitution among production inputs and no economies of scale are possible. Second, each production function incorporates fixed, invariant technology. Such an assumption may be questionable in the case of some sectors, such as agriculture, where technological changes occur regularly. This concern is offset in part by the slow, gradual technological changes that are typical in some other sectors. Third, I-O does not model any price effects that might be important to a region. Finally, I-O assumes that resources that become unemployed or employed due to a change in final demand have no alternative employment.

The IMPLAN database contains 528 sectors at the national level. While this is a large number of sectors, some sectors contain a wide range of products or services and the production functions reflect the average or aggregate production technology for the goods or services produced. The wind-power industry is contained in the electric services sector, which includes all methods for producing electricity. Because the wind industry is relatively small, the production technologies of other methods of producing electricity are predominate in the production function. However, the system does permit the introduction of additional production functions if the individual production technical relationships can be specified.

The IMPLAN database is developed from national, state, and county-level data sets, with the national level used as a control. A disaggregation procedure, which has proven quite reliable, is used to insure that the state data sets add up to the national totals, and that the county data sets add up to their respective state totals. There are occasional instances where apparent anomalies occur, particularly in counties with very small economies and particularly with very small sectors within these counties. Some of these anomalies are the result of the way ES202 and county business patterns data are collected and processed. Some may be attributed to the disaggregation procedure. Because counties with very small economies were included in this study, there were some instances where a sector was expected to be in the county data set, but was not present. A common reason for this occurrence is that the county activity is a part of a larger economic entity and the economic activity is reported in the county where its principal office is located.

IMPLAN MODEL OUTPUT

MODEL BASE DATA

Base data for the Mendocino and Sonoma county IMPLAN models used in this analysis are displayed in detail on the following pages. Table A displays the base data for the Mendocino County IMPLAN model developed for this study. Table B includes the model base data for Sonoma County. Because the model data is from 2000, the dollar amounts displayed here are all in year 2000 dollars.

The elements included in the tables and other definitions are described below:

Industry Output: Represents the total value of production by industry for the given year. MIG derives these data from a number of sources, including Bureau of Census economic censuses, Bureau of Economic Analysis output estimates, and the Bureau of Labor Statistics employment projections.

Employment: Represents the annual average number of jobs for each industry, and includes both full-time and part-time workers. These employment numbers also include the self-employed. These data come from ES202 employment security data, supplemented by county business patterns and REIS data.

Employee Compensation: Represents the total payroll costs of each industry, and includes the wages and salaries of workers who are paid by employers, as well as benefits, such as health and life insurance, retirement payments, and non-cash compensation. These data are derived from ES202 and REIS data.

Proprietor Income: Represents payments received by the self-employed as income, and includes income received by private business owners, doctors, lawyers, and others self-employed. These data are derived from self-employed income reported on federal tax forms.

Other Property Income: Represents payments to individuals in the form of rents received for property, royalties from contracts, and dividends paid by corporations, as well as profits earned by corporations. These data are derived from U.S. Bureau of Economic Analysis Gross State Product data.

Indirect Business Tax: Represents excise taxes, property taxes, fees, licenses, and sales taxes paid by businesses, or any taxes that occur during the normal operation of a business, except taxes on profit or income. These data are derived from U.S. Bureau of Economic Analysis Gross State Product data.

Total Value Added: Represents the sum of the four sub-components: 1) Employee Compensation, 2) Proprietor Income, 3) Other Property Type Income, and 4) Indirect Business Taxes.

Institutions: Institutions are households, governments, and capital. Together with exports they comprise final demand (consumption).

Personal Income: income from all sources, including employment income, capital income, and transfer payments.

Household Income: Income to households including employment income, capital income, and transfer payments, net of taxes and savings; disposable income.

Table A Mendocino County IMPLAN Model – Detailed Base Data

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
1	Dairy Farm Products	8.279	83	1.170	5.278	0.930	0.078	7.455
2	Poultry and Eggs	16.388	122	1.807	3.172	1.762	0.158	6.900
3	Ranch Fed Cattle	3.588	99	0.378	1.413	0.294	0.224	2.309
4	Range Fed Cattle	3.099	94	0.327	1.345	0.239	0.183	2.094
5	Cattle Feedlots	0.206	2	0.022	0.123	0.023	0.018	0.186
6	Sheep, Lambs and Goats	0.603	75	0.064	0.334	0.057	0.044	0.498
7	Hogs, Pigs and Swine	0.397	8	0.042	0.076	0.028	0.021	0.167
8	Other Meat Animal Products	0.074	2	0.007	0.019	0.006	0.005	0.036
9	Miscellaneous Livestock	1.202	72	0.245	0.298	0.149	0.027	0.719
13	Hay and Pasture	2.404	140	0.099	1.153	0.820	0.290	2.362
16	Fruits	75.931	1,863	30.417	9.129	11.808	3.438	54.792
17	Tree Nuts	0.204	4	0.079	0.061	0.052	0.008	0.201
18	Vegetables	10.905	142	3.141	3.771	3.378	0.469	10.758
22	Forest Products	8.097	167	0.394	1.808	3.798	0.318	6.318
23	Greenhouse and Nursery Products	14.820	289	6.263	2.938	5.099	0.198	14.498
24	Forestry Products	6.298	71	1.606	1.339	2.139	0.667	5.752
25	Commercial Fishing	9.209	231	2.014	3.577	2.766	0.287	8.643
26	Agricultural, Forestry, Fishery Services	30.100	1,342	10.587	3.437	3.391	0.769	18.185
27	Landscape and Horticultural Services	20.771	406	5.506	2.718	4.394	0.543	13.160
38	Natural Gas & Crude Petroleum	9.155	24	0.900	0.667	2.311	0.456	4.335
40	Dimension Stone	0.486	5	0.106	0.072	0.120	0.015	0.313
41	Sand and Gravel	1.120	10	0.292	0.166	0.249	0.035	0.742
48	New Residential Structures	154.441	977	19.196	7.515	4.503	1.056	32.270
49	New Industrial and Commercial Buildings	72.231	598	17.364	7.404	2.004	0.555	27.326
50	New Utility Structures	15.751	146	4.327	1.840	0.601	0.088	6.856
51	New Highways and Streets	13.856	122	3.468	1.466	0.636	0.091	5.662
53	New Mineral Extraction Facilities	5.689	82	2.951	0.394	0.233	0.289	3.867
54	New Government Facilities	51.436	327	12.846	5.580	2.209	0.324	20.960
55	Maintenance and Repair, Residential	56.139	409	10.247	4.435	2.191	0.229	17.102
56	Maintenance and Repair Other Facilities	62.261	975	27.970	12.047	3.426	0.297	43.740
58	Meat Packing Plants	0.601	2	0.013	0.001	0.002	0.001	0.016
67	Canned Fruits and Vegetables	0.742	4	0.073	0.003	0.068	0.003	0.147
69	Pickles, Sauces, and Salad Dressings	2.369	10	0.146	0.007	0.419	0.011	0.583
75	Blended and Prepared Flour	0.238	1	0.008	0.000	0.002	0.001	0.011
78	Prepared Feeds, N.E.C	0.615	2	0.014	0.001	0.005	0.001	0.020
79	Bread, Cake, and Related Products	3.570	22	0.683	0.029	0.441	0.020	1.172
80	Cookies and Crackers	13.051	86	2.424	0.161	2.693	0.094	5.373
91	Malt Beverages	17.322	66	2.049	0.097	3.289	3.056	8.491
93	Wines, Brandy, and Brandy Spirits	189.895	870	26.209	0.562	17.628	28.478	72.878
95	Bottled and Canned Soft Drinks & Water	0.660	2	0.060	0.003	0.041	0.004	0.107
97	Canned and Cured Sea Foods	0.549	5	0.050	0.002	0.013	0.002	0.067
98	Prepared Fresh Or Frozen Fish Or Seafood	36.149	243	3.673	0.190	0.734	0.168	4.765
99	Roasted Coffee	1.946	4	0.058	0.002	0.151	0.007	0.219
101	Manufactured Ice	0.158	4	0.060	0.002	0.026	0.001	0.089
103	Food Preparations, N.E.C	0.604	4	0.058	0.003	0.045	0.002	0.108
108	Broadwoven Fabric Mills and Finishing	0.460	4	0.081	0.008	0.022	0.003	0.113
117	Carpets and Rugs	13.928	76	2.187	0.309	1.291	0.129	3.916
124	Apparel Made From Purchased Materials	3.213	31	0.540	0.046	0.107	0.011	0.704
128	Canvas Products	0.184	3	0.059	0.006	0.015	0.001	0.081

Table A Mendocino County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
130	Automotive and Apparel Trimmings	3.841	29	0.425	0.072	0.111	0.018	0.626
133	Logging Camps and Logging Contractors	95.740	615	20.831	2.741	18.427	1.205	43.204
134	Sawmills and Planing Mills, General	260.083	1,368	57.022	7.209	20.962	3.226	88.419
137	Millwork	18.283	206	4.421	0.562	0.447	0.134	5.565
138	Wood Kitchen Cabinets	10.251	112	3.953	0.467	0.795	0.105	5.319
140	Structural Wood Members, N.E.C	12.650	110	3.460	0.385	0.640	0.121	4.606
142	Wood Pallets and Skids	11.815	137	4.405	0.492	0.734	0.119	5.751
143	Mobile Homes	0.402	4	0.099	0.013	0.028	0.005	0.146
144	Prefabricated Wood Buildings	0.564	5	0.127	0.014	0.022	0.005	0.168
145	Wood Preserving	7.269	21	1.022	0.119	0.605	0.088	1.834
146	Reconstituted Wood Products	103.057	360	18.811	2.927	16.886	1.269	39.892
147	Wood Products, N.E.C	3.643	35	0.929	0.103	0.295	0.035	1.362
174	Newspapers	6.787	95	1.863	0.432	0.623	0.067	2.986
175	Periodicals	3.554	30	0.450	0.119	0.195	0.019	0.783
176	Book Publishing	1.696	9	0.181	0.049	0.140	0.013	0.382
178	Miscellaneous Publishing	0.382	3	0.090	0.025	0.070	0.004	0.189
179	Commercial Printing	5.893	59	1.094	0.289	0.249	0.049	1.680
191	Plastics Materials and Resins	1.283	2	0.051	0.005	0.038	0.004	0.098
199	Toilet Preparations	0.474	2	0.047	0.006	0.076	0.003	0.132
203	Fertilizers, Mixing Only	10.468	31	1.460	0.150	0.510	0.123	2.243
220	Miscellaneous Plastics Products	0.361	2	0.078	0.001	0.031	0.003	0.112
230	Glass and Glass Products, Exc Containers	0.681	6	0.166	0.038	0.091	0.007	0.302
235	Clay Refractories	0.315	4	0.071	0.014	0.018	0.003	0.106
243	Concrete Products, N.E.C	3.981	29	1.068	0.224	0.349	0.061	1.702
244	Ready-mixed Concrete	0.355	3	0.058	0.013	0.022	0.004	0.096
250	Minerals, Ground Or Treated	0.329	2	0.078	0.018	0.069	0.004	0.169
253	Nonmetallic Mineral Products, N.E.C.	0.299	3	0.076	0.016	0.034	0.003	0.129
282	Fabricated Structural Metal	42.163	248	9.818	0.836	5.991	0.429	17.075
286	Architectural Metal Work	0.626	8	0.188	0.016	0.125	0.006	0.334
288	Miscellaneous Metal Work	3.460	9	0.219	0.018	0.148	0.022	0.407
289	Screw Machine Products and Bolts, Etc.	0.351	3	0.071	0.007	0.047	0.003	0.127
294	Metal Stampings, N.E.C.	0.468	3	0.075	0.007	0.046	0.003	0.130
295	Plating and Polishing	0.143	3	0.070	0.006	0.038	0.001	0.116
296	Metal Coating and Allied Services	0.453	3	0.073	0.007	0.061	0.003	0.145
303	Pipe, Valves, and Pipe Fittings	7.663	62	2.402	0.210	0.573	0.062	3.247
304	Miscellaneous Fabricated Wire Products	2.054	20	0.679	0.067	0.134	0.016	0.898
305	Metal Foil and Leaf	41.963	55	1.527	0.180	2.718	0.237	4.662
321	Special Dies and Tools and Accessories	0.962	11	0.437	0.019	0.037	0.008	0.501
327	Woodworking Machinery	6.897	59	2.421	0.074	0.146	0.055	2.696
331	Special Industry Machinery N.E.C.	0.665	2	0.055	0.005	0.016	0.002	0.078
337	Industrial Furnaces and Ovens	35.551	249	12.657	0.449	1.094	0.301	14.501
347	Refrigeration and Heating Equipment	0.425	2	0.065	0.002	0.020	0.003	0.090
349	Service Industry Machines, N.E.C.	7.791	47	1.622	0.053	0.587	0.063	2.326
351	Fluid Power Cylinders & Actuators	9.112	46	2.052	0.063	0.296	0.075	2.486
354	Industrial Machines N.E.C.	4.069	41	1.416	0.061	0.163	0.032	1.673
355	Transformers	4.385	45	0.912	0.081	0.326	0.026	1.344
370	Radio and TV Receiving Sets	0.310	2	0.049	0.004	0.006	0.002	0.060
372	Telephone and Telegraph Apparatus	0.787	2	0.046	0.004	0.041	0.002	0.093
386	Motor Vehicle Parts and Accessories	2.629	12	0.453	0.079	0.154	0.009	0.696

Table A Mendocino County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
391	Aircraft and Missile Equipment,	0.506	3	0.206	0.017	0.040	0.005	0.268
393	Boat Building and Repairing	0.407	3	0.136	0.010	0.021	0.004	0.171
395	Motorcycles, Bicycles, and Parts	5.430	39	1.401	0.124	0.344	0.038	1.907
403	Mechanical Measuring Devices	5.853	49	1.572	0.034	0.082	0.047	1.735
409	Dental Equipment and Supplies	2.475	14	0.412	0.006	0.031	0.019	0.468
411	Electromedical Apparatus	1.498	6	0.292	0.007	0.027	0.012	0.338
415	Jewelry, Precious Metal	0.171	2	0.017	0.002	0.014	0.001	0.034
420	Games, Toys, and Children's Vehicles	0.064	1	0.014	0.002	0.008	0.001	0.025
429	Signs and Advertising Displays	0.673	9	0.161	0.015	0.056	0.005	0.237
433	Railroads and Related Services	2.838	36	0.051	0.000	0.015	0.003	0.069
434	Local, Interurban Passenger Transit	1.711	53	0.561	0.218	0.153	0.033	0.965
435	Motor Freight Transport and Warehousing	81.479	742	18.681	7.468	8.222	1.080	35.452
436	Water Transportation	0.342	2	0.017	0.002	0.007	0.002	0.028
437	Air Transportation	12.122	115	4.897	0.164	1.259	0.904	7.224
439	Arrangement Of Passenger Transportation	1.350	26	0.329	0.372	0.231	0.040	0.973
441	Communications, Except Radio and TV	52.442	177	8.772	4.157	14.022	2.869	29.820
442	Radio and TV Broadcasting	7.702	62	1.191	0.576	0.400	0.080	2.246
444	Gas Production and Distribution	124.034	127	8.575	3.210	12.173	6.624	30.582
445	Water Supply and Sewerage Systems	2.065	16	0.366	0.179	0.580	0.140	1.265
446	Sanitary Services and Steam Supply	2.021	11	0.397	0.208	0.240	0.370	1.215
447	Wholesale Trade	92.947	1,119	35.359	3.302	11.967	13.169	63.798
448	Building Materials & Gardening	26.072	561	12.004	2.431	4.166	4.290	22.891
449	General Merchandise Stores	25.360	811	11.730	0.287	3.930	4.047	19.995
450	Food Stores	85.364	1,580	42.013	8.731	13.250	13.643	77.637
451	Automotive Dealers & Service Stations	57.705	830	21.919	3.825	8.668	8.925	43.338
452	Apparel & Accessory Stores	5.186	152	1.693	0.370	0.804	0.828	3.694
453	Furniture & Home Furnishings Stores	10.039	236	4.508	0.476	1.530	1.575	8.089
454	Eating & Drinking	101.569	2,718	33.212	5.814	9.369	6.755	55.151
455	Miscellaneous Retail	79.255	1,872	25.259	12.696	11.758	12.107	61.820
456	Banking	123.955	638	22.308	1.618	56.155	2.004	82.085
457	Credit Agencies	12.963	401	4.040	2.306	-0.553	0.389	6.182
458	Security and Commodity Brokers	10.044	45	5.344	0.542	-1.222	0.414	5.077
459	Insurance Carriers	19.269	216	5.834	0.000	3.370	0.943	10.147
460	Insurance Agents and Brokers	10.663	259	4.054	2.614	1.607	0.114	8.389
461	Owner-occupied Dwellings	200.024	0	0.000	0.000	125.578	25.937	151.514
462	Real Estate	182.249	1,105	6.838	17.839	83.399	21.564	129.639
463	Hotels and Lodging Places	78.700	1,705	24.740	5.251	11.388	5.327	46.706
464	Laundry, Cleaning and Shoe Repair	10.623	555	2.409	4.799	0.609	0.272	8.089
466	Beauty and Barber Shops	6.054	218	1.121	2.358	0.237	0.073	3.789
467	Funeral Service and Crematories	13.727	181	2.592	5.441	1.058	0.391	9.483
468	Miscellaneous Personal Services	12.608	196	0.804	1.625	0.903	0.253	3.586
469	Advertising	1.937	15	0.724	0.230	0.137	0.020	1.110
470	Other Business Services	24.399	237	5.414	1.713	3.205	0.376	10.706
471	Photofinishing, Commercial Photography	4.434	56	0.631	0.203	0.325	0.071	1.231
472	Services To Buildings	13.501	409	3.338	1.011	1.068	0.215	5.632
473	Equipment Rental and Leasing	16.287	140	3.699	1.043	2.249	0.486	7.477
474	Personnel Supply Services	12.068	386	8.455	2.875	0.292	0.229	11.851
475	Computer and Data Processing Services	19.981	183	9.586	5.315	1.265	0.304	16.470
476	Detective and Protective Services	1.791	136	0.890	0.259	0.099	0.023	1.271

Table A Mendocino County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
477	Automobile Rental and Leasing	2.879	32	0.554	0.324	0.804	0.228	1.909
478	Automobile Parking and Car Wash	2.207	51	0.552	0.302	0.637	0.102	1.593
479	Automobile Repair and Services	52.898	593	11.914	6.528	9.336	2.518	30.296
480	Electrical Repair Service	21.569	272	3.590	3.949	1.359	0.768	9.666
481	Watch, Clock, Jewelry and Furniture Repair	0.347	7	0.039	0.043	0.023	0.014	0.119
482	Miscellaneous Repair Shops	12.082	208	2.073	2.189	1.044	0.332	5.637
483	Motion Pictures	11.400	157	1.394	1.573	0.510	0.122	3.598
484	Theatrical Producers, Bands Etc.	2.199	44	0.238	0.185	0.071	0.044	0.537
485	Bowling Alleys and Pool Halls	0.538	32	0.154	0.084	0.037	0.045	0.319
487	Racing and Track Operation	0.360	14	0.056	0.044	0.027	0.060	0.187
488	Amusement and Recreation Services, N.E.C.	35.361	1,155	9.840	5.167	5.464	1.984	22.455
489	Membership Sports and Recreation Clubs	0.156	9	0.033	0.017	0.002	0.004	0.055
490	Doctors and Dentists	95.968	1,301	40.713	12.197	6.863	1.148	60.921
491	Nursing and Protective Care	17.350	438	9.527	2.942	0.468	0.438	13.376
492	Hospitals	63.876	906	29.676	9.097	2.267	0.230	41.272
493	Other Medical and Health Services	15.011	300	5.346	1.623	1.344	0.260	8.573
494	Legal Services	17.343	219	5.423	7.320	0.607	0.156	13.505
495	Elementary and Secondary Schools	4.146	166	2.366	0.246	0.000	0.000	2.613
497	Other Educational Services	2.738	53	0.915	0.085	0.113	0.083	1.195
498	Job Trainings & Related Services	6.972	198	3.295	0.000	0.020	0.014	3.330
499	Child Day Care Services	4.742	112	1.573	0.000	0.134	0.049	1.757
500	Social Services, N.E.C.	42.847	852	15.161	0.000	0.287	0.047	15.494
501	Residential Care	9.833	363	5.991	0.000	0.077	0.085	6.154
502	Other Nonprofit Organizations	5.090	209	2.534	0.092	0.001	0.032	2.660
503	Business Associations	1.967	44	1.417	0.000	0.007	0.001	1.426
504	Labor and Civic Organizations	13.972	657	11.506	0.000	0.000	0.002	11.508
505	Religious Organizations	5.985	52	0.344	0.000	0.000	0.000	0.344
506	Engineering, Architectural Services	9.987	128	2.560	0.811	0.211	0.053	3.636
507	Accounting, Auditing and Bookkeeping	21.868	680	5.822	10.454	0.958	0.196	17.430
508	Management and Consulting Services	15.523	226	4.542	1.461	0.596	0.087	6.686
509	Research, Development & Testing Services	6.234	133	2.050	0.690	0.092	0.052	2.884
510	Local Government Passenger Transit	1.198	30	1.151	0.000	-5.084	0.000	-3.932
511	State and Local Electric Utilities	6.087	10	0.714	0.000	1.964	0.000	2.677
512	Other State and Local Govt. Enterprises	36.093	166	8.796	0.000	6.044	0.000	14.840
513	U.S. Postal Service	11.578	157	9.356	0.000	-0.972	0.000	8.384
519	Federal Government - Military	6.655	186	3.924	0.000	2.731	0.000	6.655
520	Federal Government - Non-Military	16.234	259	13.690	0.000	2.544	0.000	16.234
522	State & Local Government - Education	132.714	3,542	132.714	0.000	0.000	0.000	132.714
523	State & Local Government - Non-Education	91.414	1,981	70.864	0.000	20.550	0.000	91.414
525	Domestic Services	6.837	735	6.738	0.000	0.000	0.000	6.738
528	Inventory Valuation Adjustment	-0.177	0	0.000	0.000	-0.139	0.000	-0.139
	Totals	**4,054.814**	**49,669**	**1,139.638**	**282.924**	**617.378**	**197.401**	**2,237.340**

Table B Sonoma County IMPLAN Model – Detailed Base Data

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen- sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
1	Dairy Farm Products	83.650	853	11.495	45.839	8.339	0.701	66.374
2	Poultry and Eggs	34.836	263	3.736	5.795	3.335	0.299	13.166
3	Ranch Fed Cattle	8.033	224	0.824	2.719	0.581	0.444	4.567
4	Range Fed Cattle	4.064	125	0.417	1.515	0.277	0.212	2.422
5	Cattle Feedlots	0.445	4	0.046	0.228	0.045	0.034	0.353
6	Sheep, Lambs and Goats	2.344	295	0.240	1.114	0.196	0.150	1.701
7	Hogs, Pigs and Swine	0.186	4	0.019	0.031	0.012	0.009	0.070
8	Other Meat Animal Products	0.130	4	0.012	0.029	0.009	0.007	0.057
9	Miscellaneous Livestock	7.089	429	1.406	1.509	0.788	0.143	3.846
11	Food Grains	0.110	4	0.006	0.038	0.042	0.011	0.098
12	Feed Grains	0.037	1	0.002	0.016	0.014	0.005	0.036
13	Hay and Pasture	7.006	473	0.322	3.321	2.396	0.846	6.885
16	Fruits	186.198	4,619	72.542	19.238	27.196	7.920	126.895
17	Tree Nuts	1.097	22	0.439	0.301	0.275	0.042	1.056
18	Vegetables	10.995	159	3.381	3.587	3.407	0.473	10.847
20	Miscellaneous Crops	0.246	11	0.032	0.074	0.050	0.012	0.167
22	Forest Products	8.144	170	0.386	1.564	3.346	0.280	5.577
23	Greenhouse and Nursery Products	88.070	1,813	37.774	15.660	29.135	1.133	83.703
24	Forestry Products	1.950	40	0.294	0.751	0.562	0.175	1.781
25	Commercial Fishing	0.914	30	0.104	0.471	0.255	0.026	0.857
26	Agricultural, Forestry, Fishery Services	59.958	2,320	22.552	6.201	6.957	1.578	37.288
27	Landscape and Horticultural Services	113.163	2,550	31.602	13.012	23.834	2.943	71.392
32	Silver Ores	0.287	14	0.470	-3.647	-0.652	-0.403	-4.232
38	Natural Gas & Crude Petroleum	157.016	291	20.183	9.119	43.170	8.516	80.987
40	Dimension Stone	27.879	148	7.522	2.695	6.855	0.856	17.929
41	Sand and Gravel	9.226	49	2.895	0.877	2.048	0.291	6.111
48	New Residential Structures	1,140.316	6,431	210.324	58.370	44.953	10.542	324.189
49	New Industrial and Commercial Buildings	584.909	3,937	190.245	57.503	20.034	5.547	273.329
50	New Utility Structures	131.887	961	47.412	14.290	6.008	0.882	68.592
51	New Highways and Streets	114.503	805	37.998	11.384	6.368	0.913	56.663
53	New Mineral Extraction Facilities	55.870	537	32.329	3.063	2.466	3.054	40.911
54	New Government Facilities	424.233	2,149	140.746	43.342	22.066	3.240	209.394
55	Maintenance and Repair, Residential	436.796	2,695	112.265	34.448	21.890	2.286	170.890
56	Maintenance and Repair Other Facilities	605.203	6,415	305.950	93.331	33.928	2.896	436.104
57	Maintenance and Repair Oil and Gas Wells	12.015	67	3.477	1.416	2.014	0.471	7.378
58	Meat Packing Plants	11.268	29	0.969	0.033	0.147	0.082	1.231
59	Sausages and Other Prepared Meats	1.904	9	0.161	0.006	0.043	0.008	0.218
60	Poultry Processing	36.405	245	9.079	0.286	1.629	0.355	11.349
62	Cheese, Natural and Processed	124.071	284	10.411	0.305	8.403	0.943	20.063
64	Ice Cream and Frozen Desserts	0.404	2	0.071	0.003	0.035	0.003	0.112
65	Fluid Milk	65.213	171	8.871	0.260	3.664	0.574	13.368
66	Canned Specialties	11.594	35	0.501	0.022	1.088	0.037	1.648
67	Canned Fruits and Vegetables	38.206	208	4.259	0.106	3.937	0.187	8.490
68	Dehydrated Food Products	109.526	574	19.371	0.420	15.989	0.671	36.451
69	Pickles, Sauces, and Salad Dressings	2.825	11	0.202	0.007	0.572	0.014	0.795
71	Frozen Specialties	0.770	5	0.095	0.003	0.093	0.004	0.194
73	Cereal Preparations	1.741	4	0.038	0.001	0.029	0.002	0.071
78	Prepared Feeds, N.E.C	26.318	65	3.132	0.117	1.054	0.277	4.580
79	Bread, Cake, and Related Products	66.570	403	13.512	0.390	8.611	0.383	22.896

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen- sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
80	Cookies and Crackers	2.836	18	0.549	0.025	0.598	0.021	1.192
82	Confectionery Products	2.379	11	0.183	0.007	0.261	0.010	0.460
91	Malt Beverages	29.537	73	3.810	0.124	6.029	5.601	15.564
93	Wines, Brandy, and Brandy Spirits	1,560.612	5,796	251.486	3.716	168.036	271.455	694.692
95	Bottled and Canned Soft Drinks & Water	28.141	84	3.335	0.104	2.257	0.208	5.904
97	Canned and Cured Sea Foods	0.382	3	0.069	0.002	0.017	0.002	0.090
98	Prepared Fresh Or Frozen Fish Or Seafood	14.361	95	1.607	0.057	0.316	0.072	2.053
100	Potato Chips & Similar Snacks	0.755	3	0.066	0.002	0.105	0.004	0.177
103	Food Preparations, N.E.C	45.064	256	6.778	0.210	5.180	0.260	12.428
108	Broadwoven Fabric Mills and Finishing	1.325	12	0.269	0.028	0.075	0.010	0.382
116	Yarn Mills and Finishing Of Textiles, N.E.C.	3.167	26	0.530	0.055	0.198	0.027	0.810
122	Cordage and Twine	6.531	57	1.809	0.060	0.368	0.076	2.313
123	Textile Goods, N.E.C	0.721	5	0.123	0.007	-0.045	0.005	0.091
124	Apparel Made From Purchased Materials	27.125	208	8.075	0.397	1.548	0.165	10.185
125	Curtains and Draperies	2.459	28	0.580	0.036	0.006	0.014	0.637
126	Housefurnishings, N.E.C	14.336	115	2.343	0.189	1.181	0.089	3.802
128	Canvas Products	2.344	29	0.914	0.055	0.232	0.017	1.218
130	Automotive and Apparel Trimmings	25.585	171	4.433	0.434	1.088	0.176	6.131
132	Fabricated Textile Products, N.E.C.	6.116	51	0.611	0.052	0.451	0.025	1.139
133	Logging Camps and Logging Contractors	2.638	19	0.526	0.072	0.467	0.031	1.095
134	Sawmills and Planing Mills, General	35.046	174	8.368	1.099	3.086	0.475	13.028
137	Millwork	12.767	113	4.407	0.583	0.448	0.134	5.572
138	Wood Kitchen Cabinets	17.946	193	6.950	0.853	1.403	0.185	9.391
140	Structural Wood Members, N.E.C	63.654	514	19.126	2.214	3.549	0.672	25.561
141	Wood Containers	10.211	112	4.450	0.521	0.651	0.104	5.725
142	Wood Pallets and Skids	12.565	145	4.666	0.542	0.781	0.127	6.115
143	Mobile Homes	0.263	3	0.066	0.009	0.019	0.003	0.098
144	Prefabricated Wood Buildings	0.624	6	0.087	0.010	0.015	0.003	0.115
145	Wood Preserving	7.308	24	0.663	0.080	0.394	0.057	1.194
146	Reconstituted Wood Products	4.171	18	0.532	0.086	0.480	0.036	1.134
147	Wood Products, N.E.C	24.325	211	7.095	0.815	2.259	0.267	10.435
148	Wood Household Furniture	9.570	95	2.902	0.344	0.830	0.075	4.152
150	Metal Household Furniture	0.840	6	0.211	0.020	0.062	0.006	0.300
152	Wood TV and Radio Cabinets	2.034	25	0.901	0.111	0.059	0.031	1.102
154	Wood Office Furniture	12.652	120	3.237	0.490	0.394	0.057	4.177
155	Metal Office Furniture	0.425	2	0.065	0.012	0.018	0.002	0.098
157	Wood Partitions and Fixtures	9.109	76	2.926	0.334	0.583	0.060	3.903
160	Furniture and Fixtures, N.E.C	0.502	3	0.066	0.009	0.044	0.002	0.121
165	Paper Coated & Laminated Packaging	4.691	16	0.924	0.069	0.701	0.051	1.745
166	Paper Coated & Laminated N.E.C.	2.549	11	0.681	0.053	0.366	0.027	1.127
172	Stationery Products	5.146	14	0.912	0.050	1.272	0.072	2.306
174	Newspapers	83.939	841	32.047	3.443	9.635	1.041	46.166
175	Periodicals	6.524	48	1.222	0.149	0.470	0.046	1.887
176	Book Publishing	15.974	71	2.585	0.325	1.776	0.163	4.849
177	Book Printing	1.779	14	0.361	0.041	0.077	0.018	0.496
178	Miscellaneous Publishing	52.791	299	16.417	2.116	11.316	0.668	30.517
179	Commercial Printing	94.286	709	29.906	3.655	6.030	1.185	40.776
180	Manifold Business Forms	1.366	8	0.384	0.047	0.149	0.020	0.600
181	Greeting Card Publishing	24.073	113	4.105	0.919	5.573	0.326	10.923

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
182	Blankbooks and Looseleaf Binder	14.224	103	3.674	0.584	1.501	0.197	5.957
183	Bookbinding & Related	0.797	13	0.296	0.036	0.048	0.008	0.389
184	Typesetting	1.140	13	0.332	0.043	0.078	0.010	0.462
185	Plate Making	0.478	9	0.315	0.041	0.039	0.006	0.401
195	Drugs	21.180	120	4.556	0.939	4.438	0.208	10.141
196	Soap and Other Detergents	15.022	56	4.041	0.423	4.325	0.180	8.969
199	Toilet Preparations	15.893	46	2.612	0.305	4.170	0.149	7.236
200	Paints and Allied Products	0.827	3	0.057	0.008	0.068	0.004	0.137
202	Nitrogenous and Phosphatic Fertilizers	18.388	52	2.675	0.136	1.531	0.191	4.534
203	Fertilizers, Mixing Only	4.347	13	0.493	0.044	0.170	0.041	0.747
209	Chemical Preparations, N.E.C	20.902	73	2.393	0.237	1.805	0.128	4.564
211	Paving Mixtures and Blocks	0.668	2	0.080	0.003	0.203	0.005	0.291
213	Lubricating Oils and Greases	3.327	7	0.486	0.019	0.149	0.033	0.687
215	Tires and Inner Tubes	0.650	5	0.138	0.004	0.030	0.016	0.188
217	Rubber and Plastics Hose and Belting	0.757	7	0.170	0.003	0.046	0.004	0.223
219	Fabricated Rubber Products, N.E.C.	22.481	134	6.387	0.109	1.795	0.189	8.480
220	Miscellaneous Plastics Products	100.742	548	22.373	0.358	9.028	0.745	32.505
224	Shoes, Except Rubber	0.873	11	0.295	0.000	0.101	0.007	0.403
226	Luggage	0.653	4	0.153	0.000	0.183	0.006	0.342
229	Leather Goods, N.E.C	4.847	72	2.471	-0.001	1.201	0.031	3.702
230	Glass and Glass Products, Exc Containers	17.164	127	4.746	0.867	2.491	0.204	8.308
234	Ceramic Wall and Floor Tile	9.825	107	3.103	0.560	0.787	0.124	4.573
240	Porcelain Electrical Supplies	9.538	93	3.454	0.604	1.265	0.094	5.417
241	Pottery Products, N.E.C	2.962	40	0.860	0.137	0.150	0.042	1.189
242	Concrete Block and Brick	3.177	16	0.786	0.148	0.430	0.061	1.426
243	Concrete Products, N.E.C	44.535	318	12.766	2.131	4.021	0.701	19.619
244	Ready-mixed Concrete	31.717	158	9.406	1.661	3.473	0.588	15.129
247	Cut Stone and Stone Products	4.369	48	1.773	0.328	0.378	0.051	2.530
249	Asbestos Products	0.372	13	0.243	0.040	0.003	0.000	0.287
253	Nonmetallic Mineral Products, N.E.C.	0.380	4	0.109	0.018	0.046	0.004	0.177
254	Blast Furnaces and Steel Mills	1.651	6	0.154	0.005	0.031	0.009	0.198
265	Aluminum Rolling and Drawing	18.761	59	3.117	0.080	0.878	0.192	4.267
269	Brass, Bronze, and Copper Foundries	0.099	4	0.110	0.002	-0.062	0.001	0.051
276	Hand and Edge Tools, N.E.C.	4.560	36	1.060	0.092	1.559	0.049	2.760
277	Hand Saws and Saw Blades	2.026	13	0.377	0.035	0.405	0.021	0.837
278	Hardware, N.E.C.	47.521	209	11.437	0.940	11.375	0.542	24.294
280	Plumbing Fixture Fittings and Trim	0.453	4	0.108	0.008	0.078	0.004	0.198
281	Heating Equipment, Except Electric	6.219	24	1.342	0.118	1.975	0.062	3.497
282	Fabricated Structural Metal	5.880	29	1.591	0.116	0.960	0.069	2.737
283	Metal Doors, Sash, and Trim	0.864	6	0.249	0.018	0.173	0.010	0.450
284	Fabricated Plate Work (Boiler Shops)	17.320	127	6.903	0.548	3.272	0.185	10.908
285	Sheet Metal Work	16.905	117	4.461	0.333	2.562	0.155	7.511
286	Architectural Metal Work	0.998	13	0.292	0.021	0.191	0.008	0.512
287	Prefabricated Metal Buildings	0.305	3	0.064	0.005	0.052	0.002	0.122
289	Screw Machine Products and Bolts, Etc.	20.840	151	5.375	0.438	3.529	0.200	9.542
290	Iron and Steel Forgings	0.133	1	0.029	0.002	0.017	0.001	0.050
294	Metal Stampings, N.E.C.	1.460	11	0.240	0.020	0.146	0.009	0.415
295	Plating and Polishing	1.254	34	0.624	0.048	0.335	0.012	1.019
296	Metal Coating and Allied Services	0.358	3	0.058	0.005	0.048	0.003	0.113

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen- sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
297	Small Arms Ammunition	0.663	12	0.251	0.016	0.247	0.063	0.576
301	Industrial and Fluid Valves	0.572	3	0.085	0.007	0.035	0.004	0.130
304	Miscellaneous Fabricated Wire Products	0.575	5	0.206	0.018	0.040	0.005	0.268
306	Fabricated Metal Products, N.E.C.	29.975	208	8.444	0.698	1.589	0.259	10.990
308	Internal Combustion Engines, N.E.C.	1.150	3	0.143	0.004	0.035	0.009	0.191
309	Farm Machinery and Equipment	4.155	21	1.055	0.026	0.384	0.038	1.503
313	Oil Field Machinery	1.666	12	0.771	0.012	0.043	0.017	0.842
315	Conveyors and Conveying Equipment	42.176	251	12.140	0.409	3.106	0.387	16.043
316	Hoists, Cranes, and Monorails	0.722	3	0.177	0.010	0.054	0.006	0.247
317	Industrial Trucks and Tractors	2.153	12	0.516	0.014	0.057	0.019	0.605
318	Machine Tools, Metal Cutting Types	24.404	189	13.774	0.475	0.887	0.282	15.418
319	Machine Tools, Metal Forming Types	0.316	3	0.088	0.003	0.005	0.002	0.098
321	Special Dies and Tools and Accessories	21.409	246	10.018	0.374	0.856	0.184	11.431
322	Power Driven Hand Tools	0.717	4	0.103	0.003	0.056	0.005	0.167
327	Woodworking Machinery	11.418	87	4.660	0.124	0.280	0.106	5.170
328	Paper Industries Machinery	0.416	4	0.093	0.003	0.011	0.003	0.110
330	Food Products Machinery	10.068	97	4.219	0.138	0.561	0.090	5.009
334	Blowers and Fans	9.842	87	3.556	0.098	0.706	0.091	4.451
335	Packaging Machinery	8.173	49	1.965	0.052	0.492	0.068	2.577
337	Industrial Furnaces and Ovens	4.724	39	1.284	0.040	0.111	0.030	1.465
338	General Industrial Machinery, N.E.C	1.162	6	0.243	0.010	0.080	0.009	0.342
339	Electronic Computers	5.137	19	1.450	0.129	0.175	0.036	1.790
340	Computer Storage Devices	49.845	165	8.228	1.038	0.356	0.290	9.912
342	Computer Peripheral Equipment,	8.623	29	1.871	0.070	0.078	0.063	2.081
349	Service Industry Machines, N.E.C.	21.957	107	6.321	0.182	2.279	0.244	9.026
352	Fluid Power Pumps & Motors	1.471	10	0.798	0.020	0.055	0.014	0.887
353	Scales and Balances	23.909	151	8.813	0.256	2.468	0.161	11.698
354	Industrial Machines N.E.C.	32.533	286	13.240	0.501	1.520	0.300	15.561
357	Motors and Generators	0.188	2	0.029	0.001	0.012	0.001	0.043
359	Relays & Industrial Controls	9.387	53	2.278	0.032	1.055	0.080	3.445
364	Electric Housewares and Fans	0.405	4	0.121	0.002	0.067	0.004	0.193
368	Wiring Devices	27.132	187	8.241	0.121	4.562	0.258	13.181
369	Lighting Fixtures and Equipment	2.645	21	0.428	0.007	0.136	0.017	0.588
370	Radio and TV Receiving Sets	19.891	128	5.039	0.100	0.568	0.161	5.868
372	Telephone and Telegraph Apparatus	823.384	1,435	164.676	3.767	136.384	6.959	311.786
373	Radio and TV Communication Equipment	81.347	250	13.025	0.211	9.549	0.551	23.335
374	Communications Equipment N.E.C.	5.068	59	2.266	0.056	0.736	0.042	3.101
376	Printed Circuit Boards	12.533	139	7.218	0.192	0.555	0.105	8.071
377	Semiconductors and Related Devices	66.531	292	20.359	0.701	12.431	0.554	34.045
378	Electronic Components, N.E.C.	69.234	264	12.468	0.315	2.937	0.555	16.275
381	Engine Electrical Equipment	0.465	3	0.083	0.002	0.036	0.003	0.123
382	Magnetic & Optical Recording Media	0.225	1	0.036	0.001	0.027	0.003	0.067
383	Electrical Equipment, N.E.C.	8.124	38	1.798	0.068	0.034	0.048	1.947
386	Motor Vehicle Parts and Accessories	136.699	590	24.510	4.098	8.288	0.502	37.398
387	Truck Trailers	0.556	4	0.101	0.012	0.036	0.002	0.151
389	Aircraft	1.514	6	0.303	0.034	0.010	0.014	0.361
391	Aircraft and Missile Equipment,	0.401	4	0.099	0.007	0.019	0.002	0.128
393	Boat Building and Repairing	1.488	12	0.470	0.031	0.071	0.012	0.585
395	Motorcycles, Bicycles, and Parts	4.125	27	1.246	0.099	0.303	0.034	1.681

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen- sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
400	Search & Navigation Equipment	34.082	153	12.224	0.077	0.575	0.400	13.275
401	Laboratory Apparatus & Furniture	0.717	3	0.112	0.001	0.010	0.006	0.129
402	Automatic Temperature Controls	10.550	120	6.411	0.052	0.155	0.117	6.735
403	Mechanical Measuring Devices	29.330	190	11.944	0.090	0.617	0.351	13.002
404	Instruments To Measure Electricity	1,192.656	4,911	517.049	3.836	22.812	13.707	557.404
405	Analytical Instruments	11.190	48	4.202	0.030	0.142	0.136	4.509
406	Optical Instruments & Lenses	37.154	261	26.596	0.196	0.461	0.442	27.696
407	Surgical and Medical Instrument	472.147	2,451	141.957	1.132	15.253	5.511	163.854
408	Surgical Appliances and Supplies	108.334	493	32.624	0.249	4.253	1.502	38.628
411	Electromedical Apparatus	4.639	20	0.980	0.008	0.090	0.040	1.118
412	Ophthalmic Goods	494.388	2,181	299.691	2.072	16.637	8.232	326.633
413	Photographic Equipment and Supplies	20.399	76	2.935	0.019	0.661	0.164	3.778
414	Watches, Clocks, and Parts	0.398	2	0.065	0.000	0.003	0.003	0.071
415	Jewelry, Precious Metal	6.733	57	1.312	0.113	1.023	0.061	2.509
417	Jewelers Materials and Lapidary Work	13.446	121	3.106	0.523	0.485	0.066	4.179
418	Musical Instruments	5.438	95	1.677	0.117	0.719	0.036	2.548
420	Games, Toys, and Children’s Vehicles	9.356	122	2.713	0.257	1.487	0.101	4.558
421	Sporting and Athletic Goods, N.E.C.	4.851	50	0.846	0.053	0.582	0.125	1.606
423	Lead Pencils and Art Goods	0.554	10	0.196	0.013	0.167	0.007	0.383
424	Marking Devices	7.402	153	3.959	0.248	1.840	0.062	6.109
425	Carbon Paper and Inked Ribbons	1.360	16	0.329	0.023	0.250	0.016	0.618
426	Costume Jewelry	0.123	3	0.027	0.003	0.051	0.001	0.082
427	Fasteners, Buttons, Needles, Pins	0.015	2	0.008	0.001	0.003	0.000	0.013
429	Signs and Advertising Displays	14.378	156	4.686	0.250	1.556	0.149	6.641
432	Manufacturing Industries, N.E.C.	26.252	207	7.728	0.524	4.601	0.319	13.172
434	Local, Interurban Passenger Transit	57.911	1,059	25.509	4.303	5.858	1.279	36.949
435	Motor Freight Transport and Warehousing	344.235	3,022	83.401	30.402	35.778	4.701	154.281
436	Water Transportation	4.973	26	0.549	0.022	0.215	0.070	0.857
437	Air Transportation	77.773	736	31.409	1.058	8.074	5.798	46.338
439	Arrangement Of Passenger Transportation	30.148	451	9.806	5.848	5.165	0.900	21.719
440	Transportation Services	8.025	116	3.508	1.864	0.579	0.069	6.019
441	Communications, Except Radio and TV	346.453	1,138	62.433	23.187	92.837	18.995	197.453
442	Radio and TV Broadcasting	43.730	232	11.493	4.352	3.583	0.714	20.141
444	Gas Production and Distribution	766.784	778	55.531	19.325	77.313	42.074	194.243
445	Water Supply and Sewerage Systems	4.306	24	0.781	0.355	1.210	0.292	2.638
446	Sanitary Services and Steam Supply	72.531	287	14.607	7.101	8.603	13.281	43.591
447	Wholesale Trade	976.738	8,571	383.905	25.303	126.647	139.372	675.226
448	Building Materials & Gardening	192.239	2,929	93.753	12.696	30.713	31.624	168.785
449	General Merchandise Stores	131.990	3,417	61.332	1.213	20.456	21.063	104.064
450	Food Stores	365.158	6,082	183.453	33.622	56.676	58.357	332.107
451	Automotive Dealers & Service Stations	468.919	4,717	187.479	21.743	70.430	72.519	352.170
452	Apparel & Accessory Stores	60.412	1,629	20.059	3.968	9.363	9.641	43.031
453	Furniture & Home Furnishings Stores	108.413	2,132	49.523	4.307	16.518	17.008	87.355
454	Eating & Drinking	541.011	13,357	186.392	28.578	51.601	37.207	303.778
455	Miscellaneous Retail	450.332	9,804	149.189	66.480	66.806	68.788	351.262
456	Banking	859.843	3,346	157.765	8.215	389.523	13.899	569.402
457	Credit Agencies	185.638	2,609	115.165	11.008	-3.593	7.719	130.298
458	Security and Commodity Brokers	156.599	785	76.914	9.353	-21.079	6.062	71.250
459	Insurance Carriers	419.173	3,218	142.475	0.000	82.310	23.025	247.810

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen- sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
460	Insurance Agents and Brokers	177.042	2,966	80.759	29.962	26.673	1.887	139.281
461	Owner-occupied Dwellings	1,253.791	0	0.000	0.000	787.146	162.577	949.722
462	Real Estate	1,531.541	7,662	83.743	123.745	700.758	181.187	1,089.433
463	Hotels and Lodging Places	188.648	3,114	66.147	9.592	28.752	13.449	117.940
464	Laundry, Cleaning and Shoe Repair	75.632	2,171	19.838	31.484	4.338	1.933	57.593
465	Portrait and Photographic Studios	22.740	496	3.620	5.817	2.067	0.580	12.084
466	Beauty and Barber Shops	74.146	2,285	15.926	26.687	2.899	0.895	46.407
467	Funeral Service and Crematories	17.353	252	3.800	6.356	1.337	0.494	11.988
468	Miscellaneous Personal Services	84.926	1,337	6.142	9.883	5.957	1.670	23.652
469	Advertising	50.675	473	19.083	3.666	3.264	0.470	26.484
470	Other Business Services	362.585	2,768	103.990	19.909	55.693	6.528	186.120
471	Photofinishing, Commercial Photography	81.671	797	18.338	3.570	8.542	1.876	32.327
472	Services To Buildings	73.936	1,543	26.037	4.771	7.566	1.523	39.897
473	Equipment Rental and Leasing	128.586	1,118	31.765	5.422	17.632	3.806	58.624
474	Personnel Supply Services	258.297	7,327	201.124	41.387	6.238	4.909	253.658
475	Computer and Data Processing Services	340.854	2,636	190.348	63.879	21.550	5.178	280.956
476	Detective and Protective Services	33.426	1,124	19.749	3.477	2.002	0.461	25.689
477	Automobile Rental and Leasing	28.613	339	6.037	2.684	7.984	2.261	18.966
478	Automobile Parking and Car Wash	40.080	803	10.949	4.551	11.568	1.855	28.922
479	Automobile Repair and Services	445.812	4,015	112.931	47.044	80.955	21.833	262.763
480	Electrical Repair Service	27.033	336	5.634	3.916	1.721	0.972	12.242
481	Watch, Clock, Jewelry and Furniture Repair	24.144	372	4.445	3.131	2.091	1.328	10.994
482	Miscellaneous Repair Shops	81.751	943	20.219	13.492	8.250	2.623	44.584
483	Motion Pictures	64.345	836	9.972	8.363	3.149	0.752	22.236
484	Theatrical Producers, Bands Etc.	24.549	378	3.923	3.228	1.206	0.739	9.096
485	Bowling Alleys and Pool Halls	2.949	120	0.893	0.515	0.218	0.266	1.891
486	Commercial Sports Except Racing	3.032	29	1.150	0.832	0.079	0.169	2.230
487	Racing and Track Operation	9.124	164	1.567	1.312	0.786	1.718	5.383
488	Amusement and Recreation Services, N.E.C.	74.189	3,054	19.692	10.956	11.160	4.052	45.859
489	Membership Sports and Recreation Clubs	14.230	520	4.447	2.431	0.278	0.507	7.663
490	Doctors and Dentists	718.345	8,012	332.209	82.424	53.776	8.992	477.402
491	Nursing and Protective Care	101.963	2,477	58.467	14.954	2.757	2.581	78.758
492	Hospitals	454.837	6,066	224.161	56.909	16.434	1.670	299.174
493	Other Medical and Health Services	201.003	3,252	79.592	20.326	19.262	3.721	122.902
494	Legal Services	159.883	1,764	58.411	59.067	5.591	1.434	124.503
495	Elementary and Secondary Schools	50.455	1,791	30.675	2.972	0.000	0.000	33.647
496	Colleges, Universities, Schools	3.965	128	2.432	0.301	0.000	0.000	2.733
497	Other Educational Services	62.978	1,325	19.200	1.654	2.355	1.739	24.947
498	Job Trainings & Related Services	33.754	819	18.448	0.000	0.111	0.081	18.639
499	Child Day Care Services	64.108	1,394	23.925	0.000	2.042	0.747	26.714
500	Social Services, N.E.C.	105.757	1,887	44.076	0.000	0.833	0.136	45.045
501	Residential Care	66.730	2,010	44.887	0.000	0.579	0.639	46.104
502	Other Nonprofit Organizations	58.506	2,224	28.174	3.768	0.009	0.395	32.346
503	Business Associations	21.903	474	15.930	0.000	0.082	0.014	16.026
504	Labor and Civic Organizations	27.594	1,547	21.788	0.000	0.000	0.004	21.793
505	Religious Organizations	41.723	337	4.814	0.000	0.000	0.000	4.814
506	Engineering, Architectural Services	250.109	2,642	89.364	17.072	6.669	1.668	114.773
507	Accounting, Auditing and Bookkeeping	133.707	3,517	51.086	48.434	5.851	1.200	106.571
508	Management and Consulting Services	245.680	3,111	90.467	17.544	10.717	1.572	120.300

Table B Sonoma County IMPLAN Model – Detailed Base Data (Continued)

	Industry	Industry Output ($millions)	Employ -ment (jobs)	Employee Compen-sation ($millions)	Proprietor Income ($millions)	Other Property Income ($millions)	Indirect Business Tax ($millions)	Total Value Added ($millions)
509	Research, Development & Testing Services	62.283	889	29.764	6.042	1.198	0.673	37.677
510	Local Government Passenger Transit	2.099	34	2.016	0.000	-5.738	0.000	-3.722
511	State and Local Electric Utilities	4.640	7	0.590	0.000	1.624	0.000	2.214
512	Other State and Local Govt. Enterprises	213.359	868	57.782	0.000	39.702	0.000	97.484
513	U.S. Postal Service	119.522	1,469	98.011	0.000	-9.102	0.000	88.908
519	Federal Government - Military	79.832	1,459	47.072	0.000	32.760	0.000	79.832
520	Federal Government - Non-Military	59.964	956	50.566	0.000	9.398	0.000	59.964
522	State & Local Government - Education	646.129	16,969	646.129	0.000	0.000	0.000	646.129
523	State & Local Government - Non-Education	478.699	6,814	371.088	0.000	107.611	0.000	478.699
525	Domestic Services	36.659	3,501	36.356	0.000	0.000	0.000	36.356
528	Inventory Valuation Adjustment	-1.169	0	0.000	0.000	-1.120	0.000	-1.120
	Totals	**28,500.229**	**270,780**	**9,172.171**	**1,660.708**	**4,199.443**	**1,444.274**	**16,476.595**

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APPENDIX F

FLOW-HABITAT ASSESSMENT STUDY

FLOW-HABITAT ASSESSMENT STUDY

Prepared for:

RUSSIAN RIVER BIOLOGICAL ASSESSMENT
EXECUTIVE COMMITTEE

Prepared by:

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November 21, 2003

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Term	*Definition*
BA	Biological Assessment
BO	Biological Opinion
CDFG	California Department of Fish and Game
cfs	cubic feet per second
CEQA	California Environmental Quality Act
D1610	Decision 1610
ESA	Federal Endangered Species Act of 1973
fps	feet per second
ft	feet
HSC	Habitat Suitability Criteria
MCRRFCD	Mendocino County Russian River Flood Control and Water Conservation Improvement District
NMFS	National Marine Fisheries Service
NOAA Fisheries	National Oceanic and Atmospheric Administration Fisheries (formerly NMFS)
NCRWQCB	North Coast Regional Water Quality Conservation Board
RMA	Resource Management Associates
RRWQM	Russian River Water Quality Model
SCWA	Sonoma County Water Agency
SWRCB	State Water Resources Control Board
TRPA	Thomas R. Payne & Associates
USACE	U.S. Army Corps of Engineers
WSTSP	Water Supply and Transmission System Project

PURPOSE

This memorandum presents methods, results, and conclusions of a fish habitat study conducted jointly by the U.S. Army Corps of Engineers (USACE), Sonoma County Water Agency (SCWA), with NOAA Fisheries (formerly National Marine Fisheries Service [NMFS]), California Department of Fish and Game (CDFG), and North Coast Regional Water Quality Control Board (NCRWQCB).

The study evaluated habitat availability at alternative flow scenarios for juvenile and fry lifestages of three species of anadromous salmonids: coho salmon, steelhead, and Chinook salmon. The results of this study will be used to assess the relative value of different flow levels that may be incorporated as part of alternative operations scenarios in the process of developing the Biological Assessment (BA). In addition, spawning habitat for steelhead and Chinook salmon was evaluated for the Russian River, but not for Dry Creek. The study area included Dry Creek between Warm Springs Dam and the Russian River confluence, and the Russian River between the Forks and the City of Cloverdale. Habitat was evaluated over a range of releases from Warm Springs and Coyote Valley dams. Habitat quality and quantity were evaluated by a panel of biologists representing the agencies listed above.

BACKGROUND

SCWA, USACE, and the Mendocino County Russian River Flood Control and Water Conservation Improvement District (MCRRFCD) are undertaking a Section 7 Consultation under the federal Endangered Species Act (ESA) with NOAA Fisheries to evaluate the effects of their operations and maintenance activities on listed species and their critical habitat. These species are coho salmon, steelhead, and Chinook salmon. SCWA, USACE, and MCRRFCD operate and maintain facilities and conduct activities related to flood control, water diversion and storage, hydroelectric power generation, and fish production.

As part of the Section 7 Consultation, USACE and SCWA will submit to NOAA Fisheries a BA that will provide the basis for NOAA Fisheries to prepare a biological opinion (BO) that will evaluate project operations.

To evaluate flow-related habitat under the State Water Resources Control Board (SWRCB) Decision 1610 (D1610) and other potential flow regimes, the USACE and SCWA collaborated with NOAA Fisheries, CDFG, and the NCRWQCB to develop information regarding how fish habitat changes with flow. Minimum flow requirements for the Russian River and Dry Creek currently in place under D1610 were developed in consideration of studies conducted by Winzler and Kelley (1980) and Barraco (1977), water supply needs, recreational interests, and other factors. The information developed in this study will be used in evaluating the potential effects of various operating scenarios on salmon and steelhead habitat in the Russian River and Dry Creek. As agreed by NOAA Fisheries, USACE, and SCWA representatives, a semiquantitative analysis of flow-related habitat was developed. Study objectives centered on the current management of rearing habitat, which likely limits fish production in the study area.

Habitat availability was determined by considering a combination of field measurements at representative study sites (includes cross-sectional transects), observations by a team of professional fishery scientists, and qualitative analysis of the available habitat at different evaluation flows.

FLOW ASSESSMENT PROCESS

The new study was initiated with development and approval of a study plan during summer 2001. Under this study plan, an expert analytical team composed of NOAA Fisheries, CDFG, and SCWA biologists (collectively the "Panel") was assembled (see Attachment A). Habitat availability at a series of study sites in both Dry Creek and the Russian River was estimated at several flows designed to encompass various flow alternatives. Habitat would be evaluated based on the direct observation of habitat conditions and the professional opinions of these biologists.

The Panel estimated habitat availability at a series of representative study sites in both Dry Creek and the Russian River at alternative flows. Study sites were chosen as representative of available habitat in the Russian River and Dry Creek. Most transects were located in riffle or run habitat types. Habitat in pools would tend to have similar availability across a wide range of flows.

METHODS

REACHES AND FLOWS EVALUATED

Field data interpreted in this document were collected during September and October 2001. Two areas were evaluated, one in the Russian River and the other in Dry Creek. The Russian River reach extended from the confluence of the mainstem and the East Fork, downstream to the city of Cloverdale. Russian River sites were evaluated during stable dam releases of 125 cfs, 190 cfs, and 275 cfs. Flows were slightly lower at the more downstream sites, likely because of diversions from the reach for agricultural and municipal use. The Russian River evaluation reach was selected because under current flow management this area is believed to have suitable habitat for Chinook salmon and steelhead. Dry Creek was evaluated from Warm Springs Dam downstream to the confluence of the Russian River. Dry Creek provides habitat for coho salmon as well as Chinook salmon and steelhead. Dry Creek sites were evaluated during stable dam release flows of 47 cfs, 90 cfs, and 130 cfs.

PLACEMENT OF STUDY SITES

The Panel identified candidate sites based on local knowledge of Panel biologists and with the use of topographic maps and aerial photography. Final selections were made during on-site visits. These visits took place when flow in Dry Creek measured 178 cfs, and while flow in the Russian River measured 146 cfs. The vast majority of land along the Russian River and Dry Creek is privately owned; study sites were limited to areas where landowners' permission to access the streams could be obtained. Locations of study sites are presented in Figures 1 and 2 (see following pages).

Within each study site, a physical data transect was placed perpendicular to the major axis of flow and marked with rebar headpins. Study sites typically extended up to 100 feet upstream and downstream of the transect. Study sites typically encompassed both riffle and run habitat, and shallow pools. Nine sites were selected on Dry Creek and thirteen sites on the Russian River. Study sites were numbered consecutively starting at the upstream end of the Dry Creek evaluation reach (Sites 1-9), and again starting at the upstream end of the Russian River evaluation reach (Sites 1-13).

COLLECTION OF PHYSICAL DATA

Physical data were collected at each transect, as directed by the Panel. At all transects, channel cross-sections were surveyed using standard methods. Elevations were established relative to semi-permanent benchmarks placed by the survey team. Data describing in-channel substrates, mean column water velocities, and water depths were collected at 10 to 25 points across each transect. This information, along with habitat suitability indices (see "*Selection of Habitat Suitability Indices,"* below) were used by Panel members as estimates of habitat availability.

SELECTION OF HABITAT SUITABILITY INDICES

The suitability of depths and velocities for the different species and lifestages were evaluated using habitat suitability criteria (HSC) developed for this study prior to the onset of field observations. These criteria define the relative value or suitability of different depths and mean column velocities to a particular species and lifestage. For this study, the criteria described the range of optimal, suitable, and unsuitable depths and velocities for fry and juvenile coho salmon, steelhead, and Chinook salmon, and for steelhead and Chinook salmon spawners. The criteria were developed based on a compilation of HSC developed for these species/lifestages from other California streams, including Battle Creek (TRPA 1991), the Mokelumne River, the Trinity River (Hampton 1988), and the Yuba River (Lower Yuba River Fisheries Management Plan, CDFG 1991).

To develop the criteria for this study, HSC from the reference studies were combined and plotted on a single graph. The outer boundaries of the overlain reference criteria were then identified, providing what is referred to as an "envelope" curve. The envelope curve encompasses the entire area of the overlain curves. In one or two instances, the resulting curves were modified based on the professional judgment of the Panel, so that the envelope was slightly narrowed. From these envelope criteria, mean column velocity and depth values that exceeded a suitability of 0.5 were considered *optimal*, mean column velocity and depth values with a suitability exceeding 0.1 were considered *suitable*, and mean column velocity and depth values with a suitability of less than 0.1 were considered *unsuitable* (Attachment B).

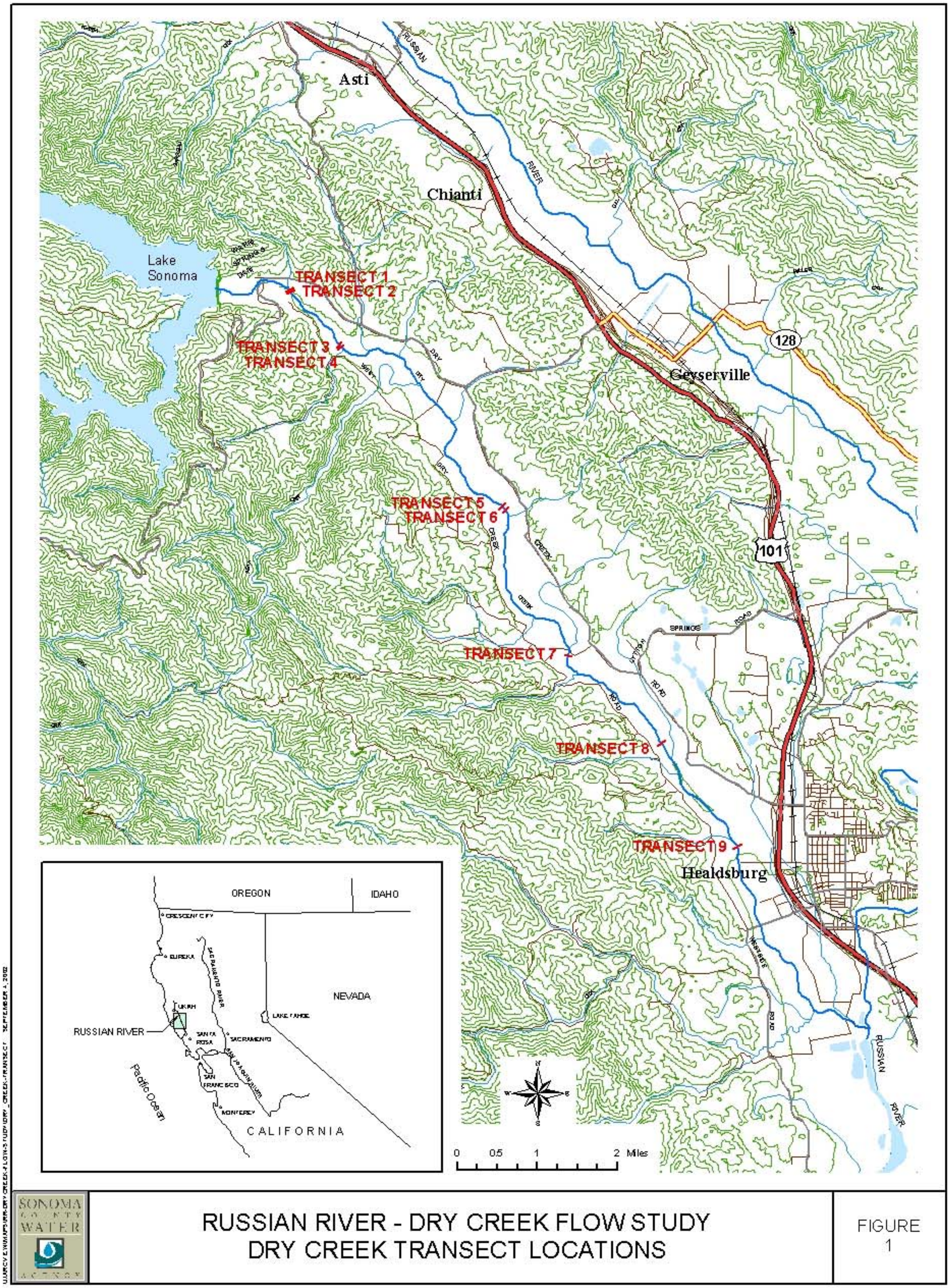

Figure 1 Russian River – Dry Creek Flow Study Dry Creek Transect Locations

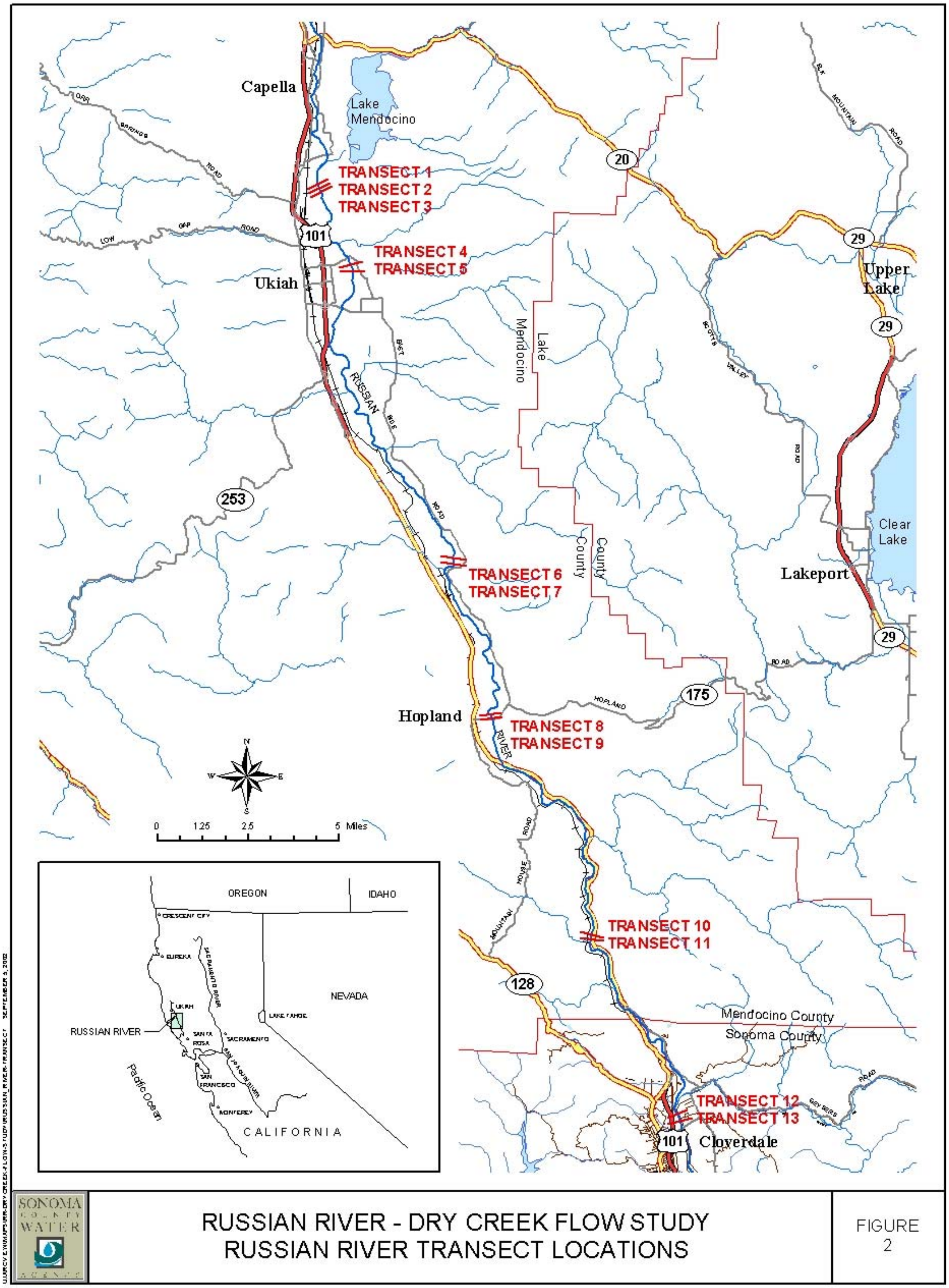

Figure 2 Russian River – Dry Creek Flow Study Russian River Transect Locations

The mean column velocity and depth criteria were used by the Panel as guidelines in estimating the availability of habitat for each species and lifestage at each study site. The criteria were not used quantitatively, but rather to provide perspective to the Panel during their assessments at each site. The evaluation of habitat availability in a particular location integrated additional factors as described in the following section.

PROFESSIONAL JUDGMENT/ASSESSMENT PROTOCOL

Field procedures for the assessment Panel involved observations of Dry Creek at nine study sites during three flow releases and comparable evaluations of the Russian River at thirteen study sites during three flow releases. The Panel followed the same route during observations for each flow, starting at the most upstream site and progressing downstream. During the first study flow (the lowest), substrate composition and cover conditions were observed, and study site boundaries were marked with flagging tape. At each flow, the Panel waded portions of the site where possible, and visually estimated approximate depths and velocities for principal sections of the site. The Panel then identified those areas likely to provide suitable habitat for each evaluation lifestage based on the HSC and other factors including adjacency to food-producing areas, influence of edge habitat, species interaction, vulnerability to predators, and channel/floodplain condition.

Estimates of habitat availability were articulated in terms of percent wetted area, as wetted area increased minimally across the range of flows studied. Team consensus was facilitated by limiting estimates to the following percent ranges: <10 percent, 10-25 percent, 25-40 percent, 40-60 percent, 60-80 percent, and >80 percent. When the Panel was unable to reach consensus on a score, a majority score was recorded, as well as the scores and names of minority dissenters.

RESULTS

The following sections summarize the results of the evaluation for Dry Creek and the Russian River. Observations at each flow, for each study site, are described in Attachment C. Attachment D provides cross-sectional plots of each of the physical data transects. Attachment E contains depth and mean column velocity measurements for each evaluation flow, and a summary of hydraulic statistics.

DRY CREEK

Habitat availability and quality was observed to vary with flows. In general, the lowest flow provided the greatest amount of suitable and optimal habitat (Tables 1 and 2). In some instances, habitat for particular species and lifestages increased as flows increased from low to intermediate levels (sites 1, 4, 5, and 7). In these cases, habitat was gained as water of sufficient depth flooded beneath overhanging vegetation or into channel-margins with appropriate physical characteristics. In some cases, increased habitat at intermediate flows resulted from situations where habitat with adequate depth and cover lacked sufficient velocities until flows rose above the low discharge.

Study sites were selected to represent habitat throughout Dry Creek, and were predominantly located in riffle and shallow run habitat, the most common habitats. Shallow pools were also included within the study sites. Larger pools also occur in Dry Creek, but are relatively rare. This habitat was not evaluated, and the results of this study may overstate changes in habitat availability in these less flow-responsive areas.

Rearing Habitat

Chinook Salmon

Suitable habitat for Chinook salmon was provided at all locations throughout the evaluation reach, and was most abundant at sites 1, 5, and 8 during low and intermediate flows. In these locations, water flowed smoothly across broad deposits of gravel and small cobble, affording these fry and small juveniles a useful combination of resting areas nestled among feeding lanes. In contrast, at the highest flow, much less habitat for Chinook salmon fry and juveniles was available (Tables 1 and 2).

Table 1 Number of Dry Creek Study Sites with the Greatest Amount of Optimal Habitat for Selected Salmonid Lifestages (comparing releases at 47 cfs, 90 cfs, and 130 cfs)

Optimal Habitat at Dry Creek				
Life Stage	Flow (cfs)			Flows with similar high scores
	47	90	130	
Chinook Fry	2	1	0	2 sites similar at 47 and 90 cfs, 4 sites similar at all 3 flows.
Chinook Juvenile	1	2	0	4 sites similar at 47 and 90 cfs, 2 sites similar at all 3 flows.
Coho Fry	1	0	1	1 site similar at 47 and 90 cfs, 6 sites similar at all 3 flows.
Coho Juvenile	1	1	0	7 sites similar at all 3 flows
Steelhead Fry	5	1	0	1 site similar at 47 and 90 cfs, 2 sites similar at all 3 flows.
Steelhead Juvenile	4	2	0	1 site similar at 47 and 90 cfs, 1 site similar at 90 and 130 cfs, 1 site similar at all 3 flows.

Table 2 Number of Dry Creek Study Sites with the Greatest Amount of Suitable Habitat for Selected Salmonid Lifestages (comparing releases at 47 cfs, 90 cfs, and 130 cfs)

Suitable Habitat at Dry Creek				
Life Stage	Flow (cfs)			Flows with similar high scores
	47	90	130	
Chinook Fry	1	1	0	4 sites similar at 47 and 90 cfs, 3 sites similar at all 3 flows.
Chinook Juvenile	1	2	0	5 sites similar at 47 and 90 cfs, 1 site similar at all 3 flows.
Coho Fry	1	1	1	2 sites similar at 47 and 90 cfs, 4 sites similar at all 3 flows.
Coho Juvenile	2	2	0	5 sites similar at all 3 flows.
Steelhead Fry	8	0	0	1 site similar at all 3 flows.
Steelhead Juvenile	4	0	1	3 sites similar at 47 and 90 cfs, 1 site similar at all 3 flows.

The data indicate that the low and intermediate flow levels provided similar amounts of habitat for Chinook salmon fry and juveniles. Fry habitat appears to have been somewhat more abundant at the low flow, while juvenile habitat appeared to be more abundant at the intermediate flow.

Coho Salmon

Within Dry Creek study sites, there was little habitat available for coho salmon. This lack of habitat arises from the poor channel structure (general lack of deep pools), and the lack of woody debris. These features constrain habitat for both fry and juvenile coho salmon. Flows are only indirectly related to this problem. This is evidenced by the fact that many of the sites showed little change in suitable and optimal habitat availability regardless of flow. At those sites where habitat did vary with flow, the high flow provided more fry habitat at two sites, while the middle and low flows each provided more fry habitat at one site each. Juvenile habitat was most abundant at three sites at the middle flow and at one site at the low flow. Pools with abundant cover are the habitat most favored by coho salmon. Pools do not represent a large portion of the habitat in Dry Creek. Therefore, under present conditions, Dry Creek provides limited amounts of habitat for coho salmon regardless of flow level.

Steelhead

Habitat for steelhead was generally more available at the low flow than at the intermediate or high flows (Tables 1 and 2). This was particularly true for steelhead fry, where eight of the nine sites provided more habitat at the lowest flow level, and only one site provided more habitat at the intermediate flow level. The highest study flow provided much less habitat for both fry and juveniles.

Habitat availability for steelhead was greater than that for Chinook salmon, and much greater than that for coho salmon. Quality habitat was found throughout the evaluation reach. Fry habitat was most abundant at Sites 1, 6, and 8, and juvenile habitat was most abundant at Sites 2, 3, 6, and 8. Generally, steelhead fry habitat overlaps that of Chinook salmon fry, but the stronger-swimming steelhead fry also make use of higher velocity areas than Chinook salmon fry. As steelhead grow beyond the fry lifestage, and into their first and then second years of life as juveniles, their habitat requirements shift toward deeper, faster areas of the stream. At the same time, instream cover provided by larger substrate particles, woody debris, water depth, or surface turbulence becomes more important. Habitat with adequate depth and velocity is provided in areas of Dry Creek even as flows increase to the highest level studied, but habitat complexity is low.

Factors Other Than Flow

Several factors limiting habitat availability in Dry Creek are independent of flow, or relate only indirectly to low-flow releases. Channel incision and loss of functional floodplains have resulted in a relatively narrow, and steep channel – often with precipitous banks. In reaches confined by bank protection efforts, the stream has little opportunity to meander, and has decreased sinuosity. Flood control operations associated with Warm Springs Dam have greatly altered the frequency, timing, duration, and magnitude of high flow events. Relatively stable summer flows, in concert with attenuated flood flows, have encouraged encroachment by willows and other riparian plants. Habitat diversity is low, and the availability of fish habitat decreases as flows rise.

Water temperatures, as predicted by the Russian River Water Quality Model (RRWQM), suggest that although summer water temperatures are warmer than optimal (>15.6°C) for salmonids in reaches of Dry Creek near the Russian River confluence (RMA 2002), they are almost always less than 19°C and therefore are still suitable for rearing. Closer to Warm Springs Dam, water temperatures are near optimal levels throughout the year, as releases are drawn from cool depths of the reservoir. In the more downstream reaches of Dry Creek, temperatures may be somewhat stressful but are not at levels considered extremely stressful.

RUSSIAN RIVER

Rearing Habitat

Habitat availability in the study sites was observed to vary with flows, and was moderately abundant overall at low and intermediate flows. At Sites 1, 4, 5, 7, 9, 10, and 11, habitat rated as high as 40-60 percent suitable for at least one species/lifestage at low flows, intermediate flows, or both. At Sites 2, 3, and 6, availability of habitat ranged no higher than 10-25 percent suitable for any species/lifestage at any flow; in general, habitat availability was greatest at the lowest flow and decreased gradually as flows increased. The availability of optimal habitat for fry and juvenile lifestages of steelhead and Chinook salmon is substantially reduced at the highest study flow (release of 275 cfs) as compared to conditions at lower study flows.

An exception occurred at Site 7, where habitat peaked during high flows, which provided 40-60 percent suitable habitat for all species/lifestages. This habitat was provided as water of sufficient depth flooded areas with gravel substrates, and where water of sufficient velocity carried into areas with unsuitably low velocities at lower flows. At this study site, optimal habitat was no greater than 10-25% for any of the evaluation species/lifestages at any flow (Table 4C – Attachment C).

Table 3 Number of Russian River Study Sites with the Greatest Amount of Optimal Habitat for Selected Salmonid Lifestages (comparing releases at 125 cfs, 190 cfs, and 275 cfs)

Optimal Rearing Habitat at Russian River				
Life Stage	Flow (cfs)			Flows with similar high scores
	125	190	275	
Chinook Fry	7	1	0	2 sites similar at 125 and 190 cfs, 3 sites similar at all 3 flows.
Chinook Juvenile	6	1	0	2 sites similar at 125 and 190 cfs, 1 site similar at 190 and 275 cfs, 3 sites similar at all 3 flows.
Steelhead Fry	8	1	0	1 site similar at 125 and 190 cfs, 3 sites similar at all 3 flows.
Steelhead Juvenile	4	2	1	1 site similar at 125 and 190 cfs, 5 sites similar at all 3 flows.

Table 4 Number of Russian River Study Sites with the Greatest Amount of Suitable Habitat for Selected Salmonid Lifestages (comparing releases at 125 cfs, 190 cfs, and 275 cfs)

Suitable Rearing Habitat at Russian River				
Life Stage	Flow (cfs)			Flows with similar high scores
	125	190	275	
Chinook Fry	10	0	1	1 site similar at 125 and 190 cfs, 1 site similar at all 3 flows.
Chinook Juvenile	8	1	1	1 site similar at 125 and 190 cfs, 2 sites similar at all 3 flows.
Steelhead Fry	11	1	1	All sites with a peak value
Steelhead Juvenile	6	1	2	1 site similar at 125 and 190 cfs, 1 site similar at 125 and 275 cfs, 2 sites similar at all 3 flows.

Study sites were chosen that were representative of riffle and run habitat in the Russian River study segment. Sites 2, 11, and 13 did contain pool habitat.

Chinook Salmon

The lowest flow provided the most habitat for Chinook salmon fry at 10 of the 13 study areas. Site 2 provided greater amounts of optimal habitat at the intermediate flow level, and Site 7 provided greater amounts of suitable habitat at the high flow level. There was very little optimal habitat at Site 7 at any flow. Availability of habitat for fry was highest at sites 1, 4 and 5. At these sites, water flowing smoothly across suitable substrates provided feeding and resting areas for fry.

For juvenile Chinook salmon, the lowest flow provided the greatest amount of suitable and optimal habitat at 8 of 13 sites (Tables 3 and 4, Table 4C - Attachment C). At Sites 2 and 4, the intermediate flow provided the most habitat. The other two sites had similar amounts of habitat at two of the three flows. Sites 1, 4, 5, 10, 11, and 12, provided the most habitat for juvenile Chinook salmon. At Sites 10 and 11, the channel was dramatically more complex than elsewhere in the Russian River. Complex velocity patterns, highly diverse and well-sorted substrates, and variable water depths provided a rich mosaic of fish habitat. Early lifestages of Chinook salmon are most often associated with low-to-zero velocity habitats. Often the margin of slow runs, as well as areas in pools, provide habitat used by these small and relatively weak-swimming salmon.

Steelhead

The lowest flow provided the greatest amount of suitable and optimal habitat for steelhead fry at 12 of the 13 sites (Tables 3 and 4, Table 4C - Attachment C). Site 2, the only exception, provided slightly more habitat at the middle flow. The lowest flow provided the greatest amount of suitable and optimal habitat for juvenile steelhead at 6 of the 13 sites (Tables 3 and 4). At three other sites, the low and intermediate flows provided about the same amount of habitat for this species/lifestage. Only Site 2 had the greatest amount of habitat at the middle flow, while Site 4 had the greatest amount of habitat at the high flow level. Availability of optimal habitat for fry and juvenile lifestages are appreciably reduced at the highest flow (275 cfs) relative to the lower study flows.

For Chinook salmon, the channel complexity observed at Sites 10 and 11 provided a rich mosaic of habitat for fry and juvenile steelhead that was unavailable in other portions of the river.

Spawning Habitat

Releases of 190 cfs provided the greatest amount of suitable habitat for Chinook salmon and steelhead spawners (Table 6). Spawning habitat was concentrated at six sites: 3, 5, 6,10, 11, and 12. Of these sites, the three upstream sites were estimated to provide approximately twice as much habitat (for both species, up to 40-60 percent suitable, and up to 25-40 percent optimal) as the three downstream sites (up to 10-25 percent suitable and optimal for both species). At Site 1, habitat availability was moderate for steelhead spawning (as high as 25-40 percent suitable, 10-25 percent optimal) and for Chinook salmon spawning (10-25 percent suitable, <10 percent optimal), but changed very little with flow. At the remaining sites, habitat availability was low, ranging no higher than 10-25 percent suitable and <10 percent optimal at any flow (Table 5C – Attachment C).

Table 5 Number of Russian River Study Sites with the Greatest Amount of Optimal Spawning Habitat for Selected Salmonid Lifestages (comparing releases of 125 cfs, 190 cfs, and 275 cfs)

Optimal Spawning Habitat at Russian River				
Life Stage	Flow (cfs)			Flows with similar high scores
	125	190	275	
Chinook Spawners	0	5	1	2 sites similar at all 3 flows, 5 sites with 0 values at all 3 flows.
Steelhead Spawners	2	3	0	1 site similar at 125 and 190 cfs, 2 sites similar at all 3 flows, 5 sites with 0 values at all 3 flows.

Table 6 Number of Russian River Study Sites with the Greatest Amount of Suitable Spawning Habitat for Selected Salmonid Lifestages (comparing releases of 125 cfs, 190 cfs, and 275 cfs)

Suitable Spawning Habitat at Russian River				
Life Stage	Flow (cfs)			Flows with similar high scores
	125	190	275	
Chinook Spawners	0	5	0	2 sites similar at 125 and 190 cfs, 2 sites similar at 190 and 275 cfs, 1 site similar at 125 and 275 cfs, 1site similar at all 3 flows, 3 sites with 0 values at all 3 flows.
Steelhead Spawners	1	3	0	4 sites similar at 125 and 190 cfs, 1 site similar at 190 and 275 cfs, 1 site similar at 125 and 275 cfs, 2 sites similar at all 3 flows, 1 site with 0 values at all 3 flows.

Factors Other Than Flow

Much of the Russian River study area appeared to provide suitable habitat for supporting juvenile steelhead throughout the year and juvenile Chinook salmon through June. For the most part, habitat is of low-to-moderate complexity, except in the vicinity of Cominsky Station (Sites 10 and 11), where the channel changes dramatically. Here, the gradient steepens, sediment sizes increase, large woody debris helps to provide cover, and the quality of habitat is high. During July and August, water temperatures may warm to 20 to 22°C. These temperatures are considered somewhat stressful, but still suitable for rearing provided adequate food is available. This may slightly offset benefits of improved channel structure.

It was apparent during this study that factors unrelated to flow levels affect salmonid habitat in the Russian River. Operation of Coyote Valley Dam, flood control-related "channel maintenance" projects, land management, historical aggregate mining, imports of water from the Eel River, and other factors all influence the quality of habitat in the evaluation reach. At Sites 1, 2, 3, 4, and 5, channelbed margins transition abruptly to precipitous banks. Nonetheless, juvenile salmonids are present in this area, and may be fairly abundant. During a weekend site visit by a member of the Panel, casual hook-and-line sampling resulted in multiple landings of juvenile Age 1+ and Age 2+ steelhead.

In many places, riparian vegetation has encroached along one or both banks. Fine sediment is abundant in substrates both near the top and bottom of the evaluation reach. Habitat diversity is low at many sites, and fish habitat is less abundant as flows rise. This occurs because the channelized nature of the river prevents the river from spreading out when flows increase. This, in combination with the lack of bed complexity and large woody debris, causes velocities to increase substantially as flows rise.

DISCUSSION

Generally speaking, the lower flow levels observed seemed to provide greater amounts of suitable and optimal habitat than the higher flow levels. On Dry Creek this was particularly true for steelhead fry and juveniles. The low and intermediate flow levels on Dry Creek provided similar amounts of habitat for fry and juvenile Chinook salmon. The amount of habitat at the 130 cfs flow level on Dry Creek provided much less suitable and optimal habitat for both species than either of the two lower flows. In most Dry Creek study sites, at least 25 percent of the stream area provided optimal habitat for steelhead fry and juveniles when flows were either 47 cfs or 90 cfs (see Attachment Table 2C); most of these cases occurred at the lowest flow. Dry Creek also provided ample nursery habitat for Chinook salmon; at least 25 percent of the stream area was rated optimal at flows of 47 cfs and 90 cfs (see Attachment Table 2C).

On the Russian River, the lowest observed flow provided the greatest amount of habitat for both Chinook salmon and steelhead fry and juveniles. The intermediate flow provided the greatest amount of habitat for spawners of both species. On the Russian River the difference in the amount of habitat was more similar among the three flow levels and there was not the tremendous decrease in habitat at the highest flow level as was observed in Dry Creek.

The Panel looked at how rearing habitat changed with flow in study sites representative of habitat throughout evaluation reaches in the Russian River and Dry Creek. Habitat in the Russian River and Dry Creek has been negatively impacted by management practices including: removal of instream woody debris, bank armoring for erosion control, operation of dams, and aggregate mining within channels. These practices have contributed to factors such as channel incision and riparian encroachment. These aspects of habitat are not integrated into this study and correction of some of the problems resulting from these activities may also improve habitat.

Today, the active channel in some areas is poorly connected to the floodplain due to down-cutting; this is especially an issue in Dry Creek. In reaches where incision has occurred, rising flows do not spread across gently-sloping channel margins and adjacent floodplain surfaces. Instead, stage rises rapidly and velocities increase quickly in comparison to what occurred in the historical channel, where relatively abundant meanders and point bars supported favorable conditions for salmon and steelhead across a wider range of flows. Historical aggregate mining practices have contributed to channel incision.

Flood control operations have altered the frequency, timing, duration, and magnitude of high flow events. Relatively stable summer flows, in concert with attenuated flood flows, have encouraged damaging encroachment by even-age stands of willows, alders and other woody riparian plants; this is especially true in Dry Creek.

Habitat quality in portions of Dry Creek and the Russian River may be reduced seasonally by warm water temperatures under current flow management conditions (RMA 2002). Near Coyote Valley Dam, Russian River water temperatures are suitable through the summer, but frequently rise to more stressful levels in September or October once releases have exhausted the cool-water pool. This event overlaps with the time of year when air temperatures decline and thus the rise in water temperature is partially mitigated. Summertime temperatures appear adequate for Chinook salmon (present through June) and steelhead as far downstream as Cloverdale. In late winter through spring, water temperatures are excellent throughout the mainstem Russian River, and habitats near Healdsburg should support pre-smolts and smolts during seaward migrations.

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ATTACHMENT A

FLOW STUDY PARTICIPANTS

Attachment A. Flow Study Participants in the Russian River/Dry Creek Flow Study.

Date	Release (cfs)	Locations	Number of Transects	Participants*
9/13/01	47	Dry Creek	9	JB, BC, TD, RF, AH, BH, PL., SL, SW
9/19/01	90	Dry Creek	9	JB, BC, RF, AH, BH, PL, SL, SW
9/20/01	130	Dry Creek	9	JB, BC, TD, RF, AH, BH, SL, SW
9/26/01	125	Russian River	13	BC, RF, AH, BH, PL, SL, TT, SW
10/1/01	190	Russian River	13	BC, TD, RF, AH, PL, SL, TT, SW
10/4/01	275	Russian River	13	BC, TD, RF, AH, PL, SL, TT

*Flow Panel	Affiliations
Jean Baldrige (JB)	ENTRIX
Bill Cox (BC)	CDFG
Tom Daugherty (TD)	NOAA
Robert Franklin (RF)	ENTRIX
Amy Harris (AH)	SCWA
Bill Hearn (BH)	NOAA
Peter LaCivita (PL)	USACE
Stacy Li (SL)	NOAA
Tom Taylor (TT)	ENTRIX
Sean White (SW)	SCWA

ATTACHMENT B

HABITAT SUITABILITY CRITERIA

Attachment B. Suitability Criteria for Russian River Target Species: Range of Depths and Velocities for Coho Salmon, Steelhead, and Chinook Salmon

Fry

Coho Salmon	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<0.3	0.31-0.49	0.5-1.7	1.71-2.5	>2.5
Velocity (fps)	-	0.0-0.1	0.11-0.6	0.61-1.0	>1.0

Steelhead	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<0.15	0.15-0.18	0.19-1.2	1.21-1.8	>1.8
Velocity (fps)	-	0.0-0.29	0.3-1.1	1.11-2.0	>2.0

Chinook Salmon	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<0.15	0.15-0.44	0.45-2.0	2.01-2.8	>2.8
Velocity (fps)	-	-	0.0-0.6	0.61-1.1	>1.1

Juveniles

Coho salmon	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<.03	0.3-0.49	0.5-1.7	1.71-2.5	>2.5
Velocity (fps)	-	0.0-0.1	0.11-0.6	0.61-1.0	>1.0

Steelhead	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<0.4	0.4-0.69	0.7-2.5	2.51-3.3	>3.3
Velocity (fps)	-	0.0-0.09	0.1-2.0	2.11-3.0	>3.0

Chinook salmon	Not Suitable	Acceptable	Optimal	Acceptable	Not Suitable
Depth (ft)	<0.55	0.55-0.89	0.9-2.1	2.11-2.5	>2.5
Velocity (fps)	<0.15	0.15-0.54	0.55-1.6	1.61-2.2	>2.2

Note: ft = feet; fps = feet per second

ATTACHMENT C

STUDY SITE SPECIFIC RESULTS

This attachment provides the results of the evaluation on a transect-by-transect table. Tables 1C – 5C of the Field Evaluation Forms are provided at the end of this attachment.

DRY CREEK

During the Flow-Habitat Assessment Study, the Panel rated the proportion of the total surface area that provided optimal or suitable habitat for each of the target species/lifestage group in each study reach. These estimates were categorized as follows: <10, 10 to 25, 26 to 40, 41 to 60, 60 to 80, and >80 percent. These estimates reflect the total surface area at a particular flow level and were not adjusted to reflect the change in total surface area that occurred between flows. However, the change in total surface area over the range of flows observed was typically small.

Transect 1

This site included the tail of a pool, a riffle, and the head of a second pool. These features were located among narrow cobble bars with sparse-to- moderate riparian plant cover. Channel gradient was low (not measured). Small gravels and sand dominated substrates within the wetted area. Riprap bank protection occurs along the west bank throughout the reach. Channel incision was noticeable, with steep banks of unconsolidated alluvium along the eastern edges of the active channel; this resulted in an abrupt transition between channel and floodplain. Minimal instream cover was provided by small woody debris, water depth, and surface turbulence. Overhanging riparian vegetation was considered part of the canopy cover, rather than part of instream cover (Table 1C).

This site had some of the best habitat observed for steelhead fry and Chinook salmon juveniles on Dry Creek. The Panel found that habitat for these two lifestages was most abundant at the middle release flow of 90 cfs. At this flow, a fair number of cobbles spread across the broad, even channel bottom provided an abundance of good feeding stations. Habitat decreased markedly at the low and high flows, relative to this flow. At the low and high flows, velocities fell below or above optimum levels, respectively, resulting in a large decrease in the proportional area of optimal and suitable habitat. Habitat for Chinook salmon fry followed a similar pattern, but habitat for juvenile steelhead was most abundant at the highest flow observed. Less than 25 percent of the surface area was considered suitable for coho salmon fry and juveniles at any flow. The high-flow condition appeared to provide the greatest proportion of optimal and suitable habitat for coho salmon fry, while the proportion of optimal and suitable habitat for juvenile coho salmon did not vary with flow.

Transect 2

This site was primarily composed of a shallow, fast riffle. Velocities were high at all three flows evaluated. The channel was mostly shallow; however, at the highest flow (130 cfs), a pool was formed behind the left bank. Channel gradient was low (not measured). Small cobbles dominated the substrate in the wetted channel. Habitat complexity and instream cover were low, particularly at the higher flows.

The habitat available at this location was generally best for juvenile steelhead, which had 40 to 60 percent optimal habitat at the lowest flow observed. Habitat was somewhat less abundant for steelhead fry, and even less abundant for Chinook salmon fry and juveniles. There was little suitable habitat for coho salmon in this area, with the peak of suitable habitat being 10 to 25 percent at the highest flow observed. As flows increased, protected resting areas adjacent to shear zones were obliterated as velocities increased. This resulted in a moderate decrease in habitat for most species and lifestages at the middle flow level. At the highest flow level, habitat was decreased to low levels for most species and lifestages.

Transect 3

This site consisted of a run with a small amount of riffle. The channel was uniform, and the substrate was dominated by medium cobbles. Habitat complexity and instream cover were low at all flows. Velocities were high at all flows, but particularly fast and uniform at the higher flows evaluated. A small amount of lower-velocity habitat was present along the channel margin. Channel gradient was low (not measured).

The habitat at the Transect 3 study area was most suitable for steelhead, providing similar amounts of habitat for juveniles and fry at all flow levels (25 to 40 percent optimal and 40 to 60 percent suitable). The proportion of optimal and suitable habitat for these lifestages gradually declined as flow increased, with the highest flow level providing less than 25 percent suitable habitat and less than 10 percent optimal habitat. Habitat was less abundant for Chinook salmon fry and juveniles, with 10 to 25 percent of the total area being rated as both suitable and optimal at both the low and middle flow levels. At the highest flow, less than 10 percent of the habitat was considered suitable for both lifestages. There was less than 10 percent suitable habitat for coho salmon at any flow level. The highest flow level provided little habitat for any species at this site, while the low flow level provided the greatest proportional area of habitat for steelhead. There was a modest decline in the amount of habitat available at the middle flow level for steelhead, but this flow provided a similar amount and quality of habitat for Chinook salmon.

Transect 4

This site consisted of a riffle. The channel was mostly uniform, and the substrate was dominated by small and medium cobbles. Habitat complexity and instream cover were low at all flows evaluated. Small cobbles dominated the substrate. Velocities were very high at all flows evaluated. Channel gradient was low (not measured).

High velocities prevailed at all flows, and because of this, very little habitat was available for any of the target species. The lowest flow level resulted in 10 to 25 percent of the area being considered optimal habitat, and as much as 25 to 40 percent being considered suitable habitat for juvenile steelhead. This flow also resulted in about 10 to 25 percent of the area being considered suitable for steelhead fry. At the two higher flows less than 10 percent of the habitat was considered suitable for either lifestage of steelhead. Less than 10 percent of the habitat was considered suitable for either Chinook salmon or coho salmon at any flow level.

Transect 5

This site was classified as a pool at the two lower flows evaluated and as a run at the highest flow. Habitat complexity and instream cover were medium at all three flows evaluated. The substrate was dominated by large gravel. The dominant substrate was classified as small-to-medium cobble at the highest flow; however, it is likely that the classifications of “large gravel” made at the lower flows were more accurate, due to greater visibility of the substrate. Embeddedness was fairly high, from 50 percent to greater than 75 percent. Riparian vegetation along both banks extended into the water and contributed to instream cover. This site did not have a dramatic change in velocity as flows increased; depth increased as flows increased. Channel gradient was low (not measured). Channel incision was noticeable, with steep banks of unconsolidated alluvium along both edges of the active channel.

The lowest observed flow provided high proportions of suitable and optimal habitat for Chinook salmon and steelhead fry (40 to 80 percent optimal habitat, and nearly 80 percent suitable habitat). This flow also provided the greatest proportion of suitable and optimal habitat for Chinook salmon juveniles, although a similar amount was available at the intermediate flow level. The intermediate flow level provided the greatest proportion of optimal and suitable habitat for steelhead juveniles and coho salmon fry and juveniles, with only a slight reduction in habitat at the low flow. The high flow at this transect resulted in a reduction in the proportion of available habitat for all species/lifestages. This reduction was large with regard to the optimal habitat of Chinook salmon fry, but modest for all other species/lifestages, where the high flow provided similar amounts of habitat to the low flow, in a few cases. This transect had the most suitable habitat observed for coho salmon in Dry Creek, with up to 40 percent of the area being suitable and 25 percent of the area being optimal at the middle flow level.

Transect 6

This site was primarily considered a run, although at the second flow evaluated (90 cfs) it was determined by many to have both riffle and run characteristics. Habitat complexity ranged from low to medium: “low-plus” at the lowest flow (47 cfs), meaning that it was somewhat better than low, but not quite a medium; medium at the second flow (90 cfs); and low at the third flow (130 cfs). Instream cover was low at all three flows. The dominant substrate was small and medium cobbles, with a few larger cobbles present. The cobbles provided some habitat value, but complexity was lacking. Channel gradient was low (not measured). Channel incision was noticeable, with steep banks of unconsolidated alluvium along both edges of the active channel.

The low flow provided the most abundant habitat for steelhead fry and juveniles of all flow levels, and similar amount to the intermediate flow for Chinook salmon juveniles. At the middle flow level, the proportional area of suitable and optimal habitat was similar to the low flow level for Chinook salmon juveniles, and improved modestly for Chinook salmon fry. The proportion of suitable and optimal steelhead fry habitat at this flow decreased by more than 20 percent. A more modest decrease was noted for steelhead juveniles. Habitat for steelhead fry was among the most abundant seen in Dry Creek, with

60 to 80 percent optimal and suitable for steelhead at the lowest flow. Suitable habitat for coho salmon lifestages was less than 10 percent of the total area at all flows.

Transect 7

This site was characterized as a run at all flows. Habitat complexity was low at all flows, although at the second flow evaluated (90 cfs), complexity was determined to be a “low-plus,” or slightly better than “low.” Instream cover was low, and consisted of water depth and surface turbulence. The dominant substrate was medium-size gravels. The determination of embeddedness varied, from 25 percent at the first flow (47 cfs) to 50 to 75 percent at the second flow (90 cfs), and “not applicable” at the third flow (130 cfs). Channel gradient was low (not measured). Velocity increased somewhat between the different flow rates, but not as much as at other sites.

The availability of suitable and optimal habitat near the transect 7 site was greatest at the intermediate flow level, when considered across all species/lifestages, although the low flow level provided similar amounts of habitat for most species, and somewhat greater amounts of habitat for steelhead fry. Optimal habitat peaked at 10 to 25 percent at both lifestages of Chinook salmon and juvenile steelhead. For all species, suitable habitat was only slightly more abundant than optimal habitat, and responded to flow in a pattern similar to that of optimal habitat. At intermediate flows, fry and small juveniles were expected to make use of instream cover along stream margins. Such cover consisted of small roots and branches. Little optimal habitat for coho salmon lifestages was available at any flow, and suitable habitat was only slightly more abundant. The amount of suitable habitat for coho salmon was less than 25 percent, while the amount of optimal habitat was less than 10 percent. Intermediate flows provided the greatest proportion of suitable and optimal habitat for both juvenile and fry coho salmon.

Transect 8

This site was characterized as a run at all flows. Habitat complexity was at least a medium at all flows, but at the second flow level (90 cfs), most of the group gave a “medium-plus” rating, while a few members of the group preferred to stay at the “medium” rating. This site had some large woody debris and undercut banks that varied in accessibility for fish at the different flows. These habitat features were a factor in both the habitat complexity and instream cover ratings. Instream cover was rated as “low-plus” at the second flow (90 cfs), but was a “medium” at the other two flows. There was some disparity in ratings of instream cover at the 90 cfs flow: the consensus of the group determined the “low-plus” rating, but some members preferred “low” and some preferred “medium.” The substrate was composed of small gravels. Embeddedness was rated 25 to 50 percent at the first flow level, but was determined not to be applicable at the second and third flows because of the small gravel size. Channel gradient was low (not measured).

Transect 8 provided some of the best coho salmon habitat available in Dry Creek. The proportion of suitable habitat for both coho salmon lifestages was greatest at the lowest flow level, with modest decreases in habitat availability at the two higher flow levels. The two higher flow levels had similar proportional availability of juvenile and fry coho salmon habitat. Habitat for Chinook salmon and steelhead lifestages was more available, with 40 to 60 percent of the area considered optimal for Chinook salmon and steelhead juveniles and up to 25 to 60 percent of the area being considered optimal for Chinook salmon and steelhead fry. This high availability of habitat is the result of relatively dense overhanging vegetation that trailed into the water along one bank, combined with a well-developed pool-riffle sequence, which increased availability. Habitat ratings were greatest at the lowest flow level for all species/lifestages, although habitat quality was similar at the middle flow for juvenile steelhead. The amount of habitat at the highest flow was generally reduced relative to the other observed flows.

Transect 9

This site was characterized as a run at all flows. Habitat complexity was low at all flows. Most of the habitat present was too uniform to be preferable for salmonid use. Instream cover was rated “medium” at the first flow (47 cfs), but low at the other two flows evaluated. The substrate was medium gravels. Embeddedness determinations varied from less than 25 percent at 47 cfs to less than 5 percent at 90 cfs and not applicable at 130 cfs. This is likely because of the medium gravel size and the decreased visibility at higher velocities. The channel gradient was low (not measured). This site was a fast, fairly shallow run. The mean velocities were high at all flows, ranging from 2.58 fps to 3.12 fps.

There was little suitable habitat in the vicinity of this transect at any flow for any of the target species/lifestages. The greatest amount of suitable habitat was 10 to 25 percent for juvenile Chinook salmon and fry and juvenile steelhead. This occurred at the lowest flow level for juvenile Chinook salmon and steelhead fry, and was similar at the middle flow level for juvenile steelhead. This area provided less than 10 percent suitable habitat for the other species and lifestages, and at other flow levels.

RUSSIAN RIVER

Coho salmon are thought to use the Russian River primarily as a passage corridor to reach tributary streams where spawning and rearing occur. Therefore, the Panel did not evaluate habitat for coho salmon in this study area.

Transect 1

This site was characterized as a run at all three flows evaluated (Table 3C). The site was located just downstream of a riffle and was the most upstream site on the Agwood property. Habitat complexity was rated low at the 190 cfs flow rate and medium at the 125 cfs and 275 cfs flow rates. Instream cover was low at all flows. The substrate ranged from small gravel to small cobbles, with several larger rocks present, but the dominant substrate was determined to be large gravel. Embeddedness was 5 to 25 percent at the 125 cfs rate, and 25 to 50 percent at the 190 cfs and 275 cfs rates. The channel gradient was low (not measured). Mean velocities ranged from 2.36 fps to 3.80 fps.

At this site, the proportional availability of suitable and optimal habitat was greatest at the lowest flow observed (Table 4C). At this flow, 25 to 40 percent of the total area was rated as suitable for fry of both Chinook salmon and steelhead, while 40 to 60 percent of the total area was rated suitable for juveniles of both species. Optimal habitat at this flow comprised 25 to 40 percent of the area for both lifestages of Chinook salmon and for steelhead fry, and 10 to 25 percent of the area for steelhead juveniles. The proportional availability of habitat generally decreased with increased flow; in most cases by 15 to 30 percent. The exception was optimal habitat for steelhead juveniles, which remained unchanged over all three flows. The greater size and swimming ability of steelhead juveniles allowed them to take advantage of deeper, swifter habitat that became more abundant as flows increased.

Transect 2

This site was characterized as a run at all flows evaluated. It was located on the Agwood property. Habitat complexity was medium at the first two flows evaluated (125 cfs and 190 cfs) and low at the third flow (275 cfs). Instream cover was medium at the first two flows and "low-plus" at the third flow, and mostly consisted of vegetation hanging into the water and depth. The determination of dominant substrate varied, from medium gravel to large gravel to small cobbles. The substrate was largely a mixture of gravels and cobble; thus, the determination of which was dominant varied. Embeddedness was classified as 50 to 75 percent, except at the first flow evaluated, when it was determined as greater than 75 percent. The channel gradient was low (not measured). Mean velocities were not as high as Transect 1, ranging from 1.14 fps to 2.40 fps.

Overall, habitat availability was lower at this site than at Transect 1. Habitat for fry and juvenile lifestages of both target species was greatest at the intermediate flow, which had 10 to 25 percent of the total area classified as optimal, while suitable habitat for juvenile steelhead and salmon ranged as high as 25 to 40 percent rated as suitable. Suitable habitat was present over 25 to 40 percent of the site for steelhead fry and 10 to 25 percent of the area for Chinook salmon fry. Habitat availability decreased modestly at the other two flow levels. This provided approximately equal proportions of suitable and optimal habitat. The higher suitability of habitat at the intermediate flow resulted from the flooding of bank margins, which were too shallow to provide suitable habitat at the low flow.

Transect 3

This site was characterized as a riffle at all three flows, and was located on the Agwood property. Habitat complexity and instream cover were low at all three flows. The dominant substrate was large gravel, and embeddedness was 5 to 25 percent. The channel gradient was low (not measured). The mean velocities ranged from 2.10 fps to 2.75 fps.

Habitat availability was low at this transect, relative to the other transect areas observed on the Russian River. The most abundant suitable habitat (about 10 to 25 percent of the area) for any species/lifestage, occurred at the lowest flow observed. Optimal habitat generally comprised less than 10 percent of the total area. Generally, inadequate depths, high velocities, or the combination of both factors reduced habitat suitability.

Transect 4

This site was classified as a run at all flows evaluated, and was located near the Perkins Street bridge. Habitat complexity and instream cover were low at all three flows. The dominant substrate varied from small to medium gravel. Embeddedness determinations varied from 50 to 75 percent to greater than 75 percent and “not applicable.” This determination likely varied because of the small/medium gravel size and the difficulty in determining embeddedness with small substrate particles. Channel gradient was low (not measured). The mean velocities ranged from 1.61 fps to 2.82 fps.

Habitat availability varied with flow, and the pattern of increase/decrease was inconsistent from species to species at this transect. Availability of suitable habitat was more stable across the range of flows than availability of optimal habitat. Suitable habitat was relatively plentiful for both lifestages of Chinook salmon at this transect during low flows. However the availability of optimal habitat was much less, indicating that habitat quality was fairly low for these species. Habitat decreased for Chinook salmon fry as flows decreased, while the intermediate flow provided the best habitat for juvenile Chinook salmon. Habitat for steelhead was not as abundant as for Chinook salmon. Steelhead fry habitat declined with flow. At the lowest flow, 25 to 40 percent of the total area was considered suitable, and less than 10 percent was considered optimal. Steelhead juvenile habitat increased with flow. At the highest flow level, 25 to 40 percent of the area was considered suitable and 10 to 25 percent of the area was considered optimal.

Transect 5

This site was classified as a riffle at all flows, and was located near the Perkins Street bridge. Habitat complexity was high at the first flow (125 cfs), medium at the second flow (190 cfs), and “medium-plus” at the third flow (275 cfs). The important habitat complexity and instream cover components included variations in velocity, vegetation along (and within) the channel margins, and the variety of substrate materials. The dominant substrate determination ranged from medium gravel to small cobble; a mixture of these various sizes was present. Embeddedness was low, rated 5 to 25 percent. Channel gradient was low (not measured). The mean velocities ranged from 1.76 to 2.73.

Optimal habitat for all target species/lifestages was moderately abundant, with 25 to 40 percent of the area being considered optimal for both lifestages of both species during the low flow release. Relative to other areas of the river that were observed, the availability of suitable and optimal habitat at Transect 5 was high for fry of both species. Similar levels of habitat were observed for steelhead juveniles as well, although habitat for this species/lifestage was present at similar levels in other portions of the river. Habitat was of uniformly high quality, as most of the suitable habitat was also characterized as being optimal. As discharges climbed, habitat became less abundant because of rising velocities. Rising flows reached onto gradually sloping gravel bars along banks and surrounding mid-channel bars. This served to moderate loss of habitat, as the low–velocity areas favored by early lifestages continued to be available, although not in the same location in the channel.

Transect 6

This site was characterized as a riffle at all three flows, and was located on the Rudick property. Habitat complexity and instream cover were low at all flows. The dominant substrate determination varied from medium gravel to small cobbles. Embeddedness determinations varied from 25 to 50 percent to 50 to 75 percent. The channel gradient was low (not measured). Mean velocities were low compared to the other sites, ranging from 1.01 fps to 1.49 fps.

Very little habitat was available in this relatively homogeneous, and shallow riffle for any species/lifestage at any flow level. This resulted from a channel that was low in complexity and small substrate sizes that were insufficient to provide substantial holding habitat for target species. The amount and quality of habitat did not vary significantly as flows changed, although a slightly higher percentage of suitable habitat was present for Chinook salmon and steelhead fry and steelhead juveniles at the lowest flow observed. Less than 10 percent of the area was considered optimal habitat for any species/lifestage at any flow.

Transect 7

This site was characterized as a run at all flows evaluated, and was located on the Rudick property. Habitat complexity and instream cover were low at all flows. An undercut bank provided habitat, but not enough to raise the instream cover rating to a medium. The substrate was uniform, composed mostly of sand and small gravels. Embeddedness was determined not to be applicable because of the small substrate size. Channel gradient was low (not measured). Mean velocities ranged from 1.56 fps to 1.85 fps.

In contrast to all other study sites, suitable habitat availability was observed to be greatest at the highest flow for juvenile Chinook salmon and steelhead. However, due to a lack of cover elements, much of this habitat was judged to be suitable (40 to 60 percent), but not optimal (<10 percent). Optimal habitat for juvenile Chinook salmon and steelhead comprised 10 to 25 percent of the total area at the intermediate flow, but less than 10 percent at the high flow. At the intermediate discharge, deeper water along undercut banks with overhanging vegetation provided a combination of protected resting areas next to shear zones affording good feeding opportunities for fish. At the high discharge, velocities in the resting areas were increased to unsuitable levels. The lowest flow provided the greatest proportion (10 to 25 percent) of suitable and optimal habitat for steelhead fry.

Transect 8

This site was classified as a run at all flows evaluated, and was located on the Fetzer property. Habitat complexity was rated low to "low-plus." The substrate was mostly sand and uniform. Small areas of cover occurred under the overhanging vegetation, but velocities tended to be high in those areas. Instream cover was rated from low to medium, largely due to the overhanging vegetation that extended into the water. Embeddedness was not applicable because of the sandy substrate. Channel gradient was low (not measured). The channel was fairly incised, with steep banks on both sides of the channel. Velocities at the site were quite high, with mean velocities ranging from 3.27 fps to 3.64 fps. Depth increased with the higher flows, but the velocity was high throughout the study.

At the low and intermediate flows, modest amounts of habitat were available to juvenile Chinook salmon and steelhead. For both species, both optimal and suitable habitat comprised 10 to 25 percent of the total area at these flows. Suitable habitat was somewhat greater for the fry lifestage of both species, with 25 to 40 percent of the area considered to be suitable. The proportion of optimal habitat for fry of both species was 10 to 25 percent, at the lowest flow. For fry, the lowest flow provided the greatest proportional area of habitat, while for juveniles the low and intermediate flows provided the same amount and quality of habitat. Higher quality habitat for juveniles was provided by a combination of slow and deep water, with overhead cover, and nearby feeding opportunities at the downstream edge of riffle habitat. Habitat availability for all species/lifestages decreased at the highest flow.

Transect 9

This site was characterized as a riffle at all flows, and was located on the Fetzer property. Habitat complexity ranged from medium to “medium-plus.” Instream cover ranged from “low-plus” to “medium-minus.” The important components of habitat complexity and instream cover included overhanging riparian vegetation and variation in velocity in the channel. The dominant substrate was medium gravel. Embeddedness was low, from 5 to 25 percent at the first flow to 25 to 50 percent at the second and third flows. Channel gradient was low (not measured), but incision was fairly high, with steep banks on both sides of the channel. Mean velocities ranged from 1.55 fps to 2.81 fps.

In the Transect 9 site, habitat availability was greatest at the lowest flow for all species/lifestages, when optimal and suitable habitat are considered in tandem. For Chinook salmon and steelhead fry, the intermediate flow provided a similar amount of optimal habitat, but less suitable habitat. Habitat decreased moderately with increasing flow for both Chinook salmon lifestages and for steelhead fry. Habitat decreased substantially for steelhead juveniles between the low and intermediate flow. At the lowest flow observed, half or more of the area in this study site was rated as suitable for juvenile steelhead, while 25 to 40 percent of the site was rated as optimal habitat for this species/lifestage. At that same discharge, optimal habitat for Chinook salmon juveniles comprised 10 to 25 percent of the area. Although velocities varied across the channel, habitat conditions favored the larger (and faster swimming) steelhead juveniles over the smaller Chinook salmon juveniles.

Transect 10

This site was located near Commisky Station, and was characterized as a run/riffle at the first flow, a riffle at the second flow, and a run at the third flow. Part of the variation in determinations was due to having two distinct channels with somewhat different characteristics. At the higher flow evaluated, both sides were functioning as a run. Habitat complexity was high at the first two flows and “high-minus” at the third flow. Instream cover varied from “high-minus” at the first flow, high at the second flow, and medium at the third flow. The substrate was composed of a variety of particle sizes, from smaller gravel/fine substrate to large boulders. The dominant size was primarily large gravel, but there were many other sizes present. Embeddedness was 5 to 25 percent at the first two flows, and 25 to 50 percent at the third flow. The channel gradient was low (not measured). Mean velocities ranged from 2.06 fps to 2.60 fps.

At Transect 10 and at the adjacent site (Transect 11), the proportion of suitable and optimal habitat were among the highest observed on the Russian River. At the lowest flow, the proportion of the area rated as optimal by the panel was 40 to 60 percent for steelhead and Chinook salmon juveniles. This same proportion was considered suitable for Chinook salmon juveniles, while 60 to 80 percent of the area was considered suitable for steelhead juveniles. A smaller proportion of the area (25 to 40 percent) was considered suitable for fry of both species. Optimal habitat comprised 25 to 40 percent of the area for steelhead fry and 10 to 25 percent of the area for Chinook salmon fry. For all species and lifestages, the proportion of habitat considered suitable and optimal decreased moderately at the intermediate flow, and substantially at the highest flow observed. However, water temperatures in this reach are thought to regularly exceed the optimal range for Chinook salmon and steelhead, although they remain suitable. During the warmer months, the benefits provided by increased channel complexity and the abundance of cover are moderately reduced by sub-optimal temperatures.

Transect 11

This site was classified as a riffle at all flows, and was located near Commisky Station. Habitat complexity ranged from "medium-plus" to high, and was highest at the lowest flow evaluated (125 cfs). Instream cover ranged from "low-plus" to "medium-minus," and was highest at the second flow evaluated (190 cfs). The substrate was composed of a variety of particle sizes, from smaller gravel/fine substrate to large boulders. The most prevalent size was large gravel. Embeddedness was 5 to 25 percent at the first and third flows, and 25 to 50 percent at the second flow. Channel gradient was low (not measured). Mean velocities ranged from 2.34 to 2.95. Depth was fairly high in some parts of this site (including a deep pool with large boulders), relative to other sites.

Habitat availability ratings at this transect are similar to those for Transect 10. Habitat availability was among the highest observed on the Russian River, with the lowest flows providing the greatest amount of habitat, and habitat decreasing modestly at the intermediate flow and substantially at the highest flow. As with Transect 10, the value of this habitat is somewhat reduced by less than optimal temperatures in the summer months. During late winter and spring periods, the high diversity of habitat at this transect likely benefits larger juveniles as they move downstream and prepare to undergo smoltification.

Transect 12

This site was characterized as a riffle at all flows, and was located near the Cloverdale Bridge. Habitat complexity was low at all flows. Instream complexity was low at the first and third flows, but was rated "lowplus" at the second flow, largely because of the presence of some deeper pools and larger cobbles, which provided some cover and variability in habitat. The substrate was composed of a variety of sizes of rocks, including medium gravel, large gravel, and small to large cobble. Embeddedness determinations varied from 25 to 50 percent to 50 to 75 percent, likely because of the variability of rock sizes. Channel gradient was low (not measured). Mean velocities were low compared to other sites, from 1.20 fps to 2.36 fps. This is probably because of the decrease in flow rate between Site 1 and Site 12.

At this site, the proportional area of habitat was greatest at low flows, for all species/lifestages. A similar proportion of habitat for juvenile steelhead was available at the intermediate flow. Habitat decreased moderately with increasing flow. The panel found that 25 to 40 percent of the area provided suitable habitat for fry of both species at the lowest flow. Optimal habitat made up 10 to 25 percent of the area at this flow. For juveniles of both species, the corresponding percentages were 10 to 25 suitable and less than 10 optimal. At the highest flow, less than 10 percent of the habitat was considered suitable for any species/lifestage. Water temperatures during warm months are likely sub-optimal for salmonids.

Transect 13

This site was characterized as a run at all three flows, and was located near the Cloverdale Bridge. Habitat complexity varied from "low-plus" to medium. Although the site did not appear to have good salmonid habitat characteristics, there was a diverse range of rock sizes and diversity in velocities that would provide important habitat. Instream cover was rated "low-plus" for the same reasons. Because of the variability of rock sizes in the substrate, it was difficult to determine one dominant substrate size; particles ranged from medium gravel to small cobbles. Embeddedness ranged from 25 to 50 percent at the second and third flows to greater than 75 percent at the first flow. Channel gradient was low (not measured). Mean velocities ranged from 0.68 fps to 1.26 fps.

At this site, the highest proportional availability of both suitable and optimal habitat occurred at the lowest flow level observed for all species/lifestages. The availability of suitable habitat decreased at the intermediate flow level for all species/lifestages, except steelhead juveniles, where it remained the same. At the highest flows, the availability of suitable habitat similar to what was available at the middle flow for all species/lifestages, except juvenile Chinook salmon, where suitable habitat continued to decrease. The proportional availability of optimal habitat at the high flow (relative to the middle flow) increased moderately for Chinook salmon fry, remained the same for Chinook salmon juveniles and steelhead fry, and decreased moderately for juvenile steelhead.

The proportional availability of suitable habitat at the low flow was 40 to 60 percent for juvenile Chinook salmon and 25 to 40 percent for the other species/lifestages. The proportional availability of optimal habitat at this flow was 25 to 40 percent for both lifestages of Chinook salmon and 10 to 25 percent for both lifestages of steelhead. At the highest flow level, suitable and optimal habitat was reduced to 10 to 25 percent and for all species/lifestages, except juvenile steelhead, for which 25 to 40 percent of the total area was rated suitable and less than 10 percent was rated optimal. Water temperatures during warm months are likely sub-optimal for salmonids. Habitat available in cooler months, when water temperatures are acceptable, would benefit pre-smolts traversing this section of the river.

Dry Creek Flow Assessment Study

Table 1C. Habitat Characteristics Observed at Dry Creek Study Sites.

	Flow	1	2	3	4	5	6	7	8	9
Habitat Type	47	Pool	Riffle	Run	Riffle	Pool	Run	Run	Run	Run
Habitat Complexity (L, M, H)		Low	Med	Low	Low	Med	Low+	Low	Med	Low
Dominant Substrate*		4	4	4/5	4/5	3	4 - 5	2	1	2
Embeddedness (%)**		25 - 50	25	<25	<5	50 - 75	<25[1]	25	25 - 50	<25
Instream Cover (Low, Med, High)		Low	Med	Low	Low	Med	Low+	Low	Med	M
Habitat Type	90	Run	Riffle	Run	Riffle	Pool	Riffle	Run	Run	Run
Habitat Complexity (Low, Med, High)		Low+	Med	Low	Low	Med	Med	Low+	Med+[4]	Low
Dominant Substrate*		4	4[2]	4	4	3	4	2	1	2
Embeddedness (%)**		25 - 50	5 - 25	5 - 25	5 - 25	>75	5 - 25	50 - 75[3]	[3]	<5
Instream Cover (Low, Med, High)		Low	Low	Low	Low	Med	Low	Low+	Low+[5]	Low
Habitat Type	130	Run	Riffle	Run	Riffle	Run	Run	Run	Run	Run
Habitat Complexity (Low, Med, High)		Low	Med[6]	Low	Low	Med	Low	Low	Med	Low
Dominant Substrate*		4	4	4	4	4/5	4/5	2	1	2
Embeddedness (%)**		25 - 50	5 - 25	5 - 25	5 - 25	25 - 50	5 - 25	n/a	n/a	n/a
Instream Cover (Low, Med, High)		Low	Low	Low	Low	Med	Low	Low	Med	Low

* **Substrate: 0** Fines<4mm, **1** Sm. Gravel 4-25mm, **2** Med. Gravel 26-50mm, **3** Lg. Gravel 51-75mm,
4 Sm. Cobble 76-150mm, **5** Med. Cobble 151-225mm, **6** Lg. Cobble 226-300mm,
7 Sm. Boulder 301-600mm, **8** Lg. Boulder>600mm, **9** Bedrock

** **Embeddedness: <5, 5-25, 25-50, 50-75, >75**

[1] TD - 25 - 50
[2] High end of range
[3] Embeddedness not as relevant with gravel substrate
[4] BH/BC/SL - rate as Med
[5] BC - Low; SL - Med
[6] BH - Med-

Dry Creek Flow Assessment Study

Table 2C. Percent of Optimal and Suitable Habitat Observed at Dry Creek Study Sites

		Flow	1 [a]	2 [b]	3 [c]	4 [d]	5 [e]	6 [f]	7 [g]	8 [h]	9 [i]
Chinook Fry	Suitable	47	40 - 60	10 - 25	10 - 25	<10	>80	10 - 25	10 - 25	40 - 60	<10
		90	40 - 60 [10]	10 - 25 [11]	10 - 25	<10	40 - 60 [10]	25 - 40 [17]	10 - 25 [10]	40 - 60	<10
		130	25 - 40 [21]	10 - 25	<10	<10	25 - 40	10 - 25	<10	10 - 25	<10
	Optimal	47	25 - 40	<10	<10	<10	60 - 80	10 - 25	<10	25 - 40	<10
		90	25 - 40 [10]	>10	<10	<10	40 - 60	10 - 25	10 - 25 [11]	10 - 25	<10
		130	<10	<10	<10	<10	<10	<10	<10	10 - 25	<10
Chinook Juvenile	Suitable	47	25 - 40	10 - 25	10 - 25	<10	40 - 60 [4]	25 - 40	10 - 25	40 - 60	10 - 25
		90	>80 [12]	10 - 25 [11]	10 - 25	<10	40 - 60	25 - 40 [16]	25 - 40	40 - 60	<10
		130	25 - 40	<10	<10	<10	25 - 40	<10	10 - 25	10 - 25	<10
	Optimal	47	<10	<10	10 - 25	<10	25 - 40	10 - 25	<10	40 - 60	<10
		90	60 - 80 [13]	>10	10 - 25	<10	25 - 40	10 - 25	10 - 25 [18]	10 - 25	<10
		130	10 - 25	<10	<10	<10	10 - 25	<10	<10	10 - 25	<10
		Flow	1 [a]	2 [b]	3 [c]	4 [d]	5 [e]	6 [f]	7 [g]	8 [h]	9 [i]
Coho Fry	Suitable	47	10 - 25	<10	<10	<10	10 - 25	<10	10 - 25	25 - 40	<10
		90	<10 [14]	>10	<10	<10	25 - 40	<10	10 - 25 [19]	10 - 25	<10
		130	10 - 25	10 - 25 [22]	<10	<10	10 - 25 [11]	<10	<10	10 - 25	<10
	Optimal	47	<10	<10	<10	<10	10 - 25	<10 [25]	<10	10 - 25	<10
		90	<10	>10	<10 [11]	<10	10 - 25	<10	<10	<10	<10
		130	10 - 25	<10	<10	<10	<10	<10	<10	<10	<10
Coho Juvenile	Suitable	47	10 - 25	10 - 25	<10	<10	10 - 25 [5]	<10	<10	25 - 40	<10
		90	10 - 25	>10	<10 [11]	<10	25 - 40	<10	10 - 25	<10	<10
		130	10 - 25	<10	<10	<10	10 - 25	<10	<10	<10	<10
	Optimal	47	<10	<10	<10	<10	>10 [5]	<10	<10	10 - 25	<10
		90	<10	>10	<10	<10	10 - 25	<10	<10	<10	<10
		130	<10	<10	<10	<10	<10	<10	<10	<10	<10
		Flow	1 [a]	2 [b]	3 [c]	4 [d]	5 [e]	6 [f]	7 [g]	8 [h]	9 [i]
Steelhead Fry	Suitable	47	60 - 80	25 - 40	40 - 60	10 - 25	<80	60 - 80	25 - 40	60 - 80	10 - 25
		90	60 - 80	10 - 25	25 - 40 [10]	<10	10 - 25	25 - 40	10 - 25	40 - 60	<10
		130	60 - 80 [11]	10 - 25	<10	<10	10 - 25	10 - 25	<10	10 - 25	<10
	Optimal	47	10 - 25	10 - 25	25 - 40 [2]	<10	40 - 60 [6]	60 - 80	10 - 25 [7]	40 - 60	<10
		90	60 - 80	>10	10 - 25 [10]	<10	10 - 25	10 - 25	10 - 25 [11]	10 - 25	<10
		130	25 - 40	<10	<10	<10	<10 [23]	<10	<10	10 - 25 [24]	<10
Steelhead Juvenile	Suitable	47	10 - 25	40 - 60 [1]	40 - 60	25 - 40 [2]	40 - 60	40 - 60	10 - 25	40 - 60 [9]	10 - 25
		90	25 - 40	25 - 40 [10]	25 - 40 [11]	<10	40 - 60	25 - 40	10 - 25	40 - 60	10 - 25
		130	40 - 60	10 - 25	10 - 25	<10	25 - 40	<10	10 - 25	25 - 40	<10
	Optimal	47	<10	40 - 60	25 - 40	10 - 25 [3]	10 - 25	25 - 40	<10	25 - 40 [8]	<10
		90	10 - 25	10 - 25	10 - 25 [11]	<10	25 - 40	10 - 25 [8,15]	10 - 25	25 - 40 [20]	<10
		130	10 - 25	<10 [10]	<10	<10	10 - 25 [26]	<10	<10	10 - 25	<10

a Canopy provides little shade; lacks complexity needed to be optimal for coho
b Velocities/depths inappropriate for chinook; good complexity for steelhead esp. on left bank
c Low habitat complexity
d Better for juvenilles than fry; steelhead scores at low end of ranges - velocities too great
e Juvenilles - low food availability = good not excellent; fry - velocities too great
f Complexity lacking, no large rocks for velocity refuge
g Flow 47: Insufficient cover - low complexity, substrate too small
Flow 90: Better for chinook vs steelhead juveniles - smaller average size = better
h Flow 47: Great habitat: high food availability, abundant cover
i Fast shallow run - velocities too great, channel structure too uniform

1 BC - 75%
2 TD - 10 - 25%
3 TD - <10%
4 SL - High end of range
5 RF - Low end of range
6 TD - 60-80%
7 BC - <10%
8 RF - One category lower
9 SW - High end of range
10 High end of range
11 Low end of range
12 AH - 60 - 80%
13 BC - >80%
14 BH - low end of range
15 BH - low end of range
16 AH - 10-25%
17 PL/BH - low end of range
18 Low habitat complexity
19 Cover provided by overhanging branches, deep water
20 Poor substrates,caliber too small
21 SW - low end of range
22 BH/SW/AH - <10%
23 too deep for higher score
24 BH/TD - <10%
25 BC - <<10%
26 no structure

Russian River Flow Assessment Study

Table 3C. Habitat characteristics at Russian River Transects.

	Flow	1	2	3	4	5	6	7	8	9	10	11	12	13
Habitat Type	125	Run	Run	Riffle	Run	Riffle	Riffle	Run	Run	Riffle	Run/Riffle	Riffle	Riffle	Run
Habitat Complexity (Low, Med, High)		M	M[5]	L	L	H	L	L	L+	M	H	H	L	M[13]
Dominant Substrate[1]		3[4]	4[6]	3	1[7]	4	4	1	2[9]	2	3[10]	Mix[12]	3	3
Embeddedness[2]		5 - 25[3]	775	5 - 25	>75	5 - 25	25 - 50	n/a	775	5 - 25	5 - 25	5 - 25	50 - 75	775
Instream Cover (Low, Med, High)		L	M	L	L	M	L	L[8]	M	M-	H-[11]		L	L+[14]
Habitat Type	190	Run	Run	Riffle	Run	Riffle	Riffle	Run	Run	Riffle	Riffle	Riffle	Riffle	Run
Habitat Complexity (Low, Med, High)		L	M	L	L	M	L	L	L	M	H	H/M[17]	L	M
Dominant Substrate[1]		3	2	3	1	4/2[15]	3	1	2	2	Mix[12]	3	4	4
Embeddedness[2]		25 - 50	50 - 75	5 - 25	n/a	5 - 25	25 - 50	n/a	50 - 75	25 - 50	5 - 25	25 - 50	25 - 50	25 - 50
Instream Cover (Low, Med, High)		L	M	L	L	M-	L	L	L	M-	H	M-	L+	L+[16]
Habitat Type	275	Run	Run	Riffle	Run	Riffle	Riffle	Run	Run	Run	Run	Riffle[19]	Riffle	Run
Habitat Complexity (Low, Med, High)		M	L+	L	L	M+	L	L	L+	M -	H-	M+	L	L+
Dominant Substrate[1]		3	3	3	2	3	2	1	2	2	3	Mix[12]	Mix[12]	4/2
Embeddedness[2]		25 - 50	50 - 75	5 - 25	50 - 75	5 - 25	50 - 75	n/a	n/a	25 - 50	25 - 50	5 - 25	25 - 50	25 - 50
Instream Cover (Low, Med, High)		L	L+	L	L	M	L	L	L+	L+	M	L+[18]	L	L+[20]

[1] **Substrate: 0** Fines<4mm, **1** Sm. Gravel 4-25mm, **2** Med. Gravel 26-50mm, **3** Lg. Gravel 51-75mm, **4** Sm. Cobble 76-150mm, **5** Med. Cobble 151-225mm, **6** Lg. Cobble 226-300mm, **7** Sm. Boulder 301-600mm, **8** Lg. Boulder>600mm, **9** Bedrock

[2] **Embeddedness: <5, 5-25, 25-50, 50-75, >75**

[3] some areas with less than 5% embeddedness, some with more than 25%

[5] BC rates H-
[6] substrate is a mixture of gravel and cobble
[7] between 1 and 2
[8] nice undercut bank, but not a large enough component to rate Med
[9] BH/TT argue for score of 1
[10] some large boulders present, some smaller rocks/fines, dominant size is a 3
[11] much more diversity than other sites - velocity, rocks, logs
[12] Mixture with equal parts 1,2,4,6
[13] Some larger rocks and small areas with diverse velocity fields

[14] improved by small boulders in substrate
[15] co-dominant
[16] small boulders in substrate
[17] extended deliberation prior to agreement
[18] some deeper pools, a few small boulders
[19] deep pool with very large boulders
[20] small boulders present, not plentiful

Table 4C. Percent of Optimal and Suitable Rearing Habitat at Russian River Transects

		Flow	1	2[a]	3	4	5	6	7	8	9	10	11	12	13
Chinook Fry	Suitable	125	25 - 40[1]	10 - 25[2]	<10	60 - 80	40 - 60	10 - 25[7]	25 - 40[8]	25 - 40	25 - 40	25 - 40[1, 7, 10]	25 - 40	25 - 40	25 - 40
		190	10 - 25[2]	10 - 25	<10	25 - 40	10 - 25	<10	<10	10 - 25	10 - 25	10 - 25	<10	10 - 25	10 - 25
		275	<10	<10	<10	10 - 25	10 - 25	<10[19]	40 - 60[21]	10 - 25[22]	10 - 25	<10[23,24]	<10	<10[25]	10 - 25[26]
	Optimal	125	25 - 40[2]	<10	<10	10 - 25	25 - 40[1]	<10	<10	10 - 25	10 - 25	10 - 25[1]	10 - 25	10 - 25[14]	25 - 40
		190	<10	10 - 25	<10	<10	10 - 25	<10	<10	<10	10 - 25	10 - 25	<10	<10	<10
		275	<10	<10	<10	<10	10 - 25	<10[19]	<10[21]	<10[22]	<10	<10[23,24]	<10	<10[25]	10 - 25[2, 26]
Chinook Juvenile	Suitable	125	40 - 60[1]	10 - 25	10 - 25	40 - 60	25 - 40[1]	<10	10 - 25[9]	10 - 25[1]	10 - 25	40 - 60	25 - 40	10 - 25	40 - 60
		190	10 - 25[1]	25 - 40	<10	40 - 60	10 - 25	<10	10 - 25	10 - 25	<10	10 - 25	10 - 25	<10	25 - 40[15]
		275	10 - 25	<10	<10	25 - 40	10 - 25	<10[19]	40 - 60[21]	10 - 25[22]	<10	10 - 25[23,24]	<10	<10[25]	10 - 25[26]
	Optimal	125	25 - 40[2]	10 - 25	<10	<10	25 - 40[2]	<10	<10	10 - 25[2]	10 - 25	40 - 60[11]	25 - 40	<10	25 - 40
		190	10 - 25[2]	10 - 25	<10	10 - 25	10 - 25	<10	10 - 25	10 - 25	<10	10 - 25	<10	<10	10 - 25
		275	<10	<10	<10	10 - 25	10 - 25	<10[19]	<10[21]	<10[22]	<10	<10[23,24]	<10	<10[25]	10 - 25[1, 26]
Steelhead Fry	Suitable	125	25 - 40[1]	<10	10 - 25	25 - 40	40 - 60	10 - 25	10 - 25	25 - 40	25 - 40	25 - 40	25 - 40	25 - 40[2]	25 - 40
		190	10 - 25	10 - 25	<10	10 - 25[1a]	25 - 40[2]	<10	<10	10 - 25	10 - 25	10 - 25	<10	10 - 25	10 - 25
		275	<10	<10	<10	10 - 25	10 - 25[17]	<10[20]	40 - 60	10 - 25	10 - 25	<10	<10	<10	10 - 25
	Optimal	125	25 - 40[2]	<10	10 - 25	<10	25 - 40	<10	10 - 25	10 - 25	10 - 25	25 - 40	25 - 40[2]	10 - 25	10 - 25
		190	<10	10 - 25	<10	<10	10 - 25	<10	<10	<10	10 - 25	10 - 25	<10	<10	10 - 25
		275	<10	<10	<10	<10	<10[18]	<10[20]	<10	<10	<10	<10	<10	<10	10 - 25
Steelhead Juvenile	Suitable	125	40 - 60	10 - 25	10 - 25[4]	10 - 25[2]	40 - 60[2, 6]	10 - 25	10 - 25	10 - 25	40 - 60	60 - 80	60 - 80[12]	10 - 25	25 - 40
		190	25 - 40	25 - 40	<10	10 - 25	25 - 40[1]	<10	10 - 25	10 - 25	<10	25 - 40[1]	25 - 40	10 - 25	25 - 40
		275	10 - 25	10 - 25[1]	10 - 25	25 - 40[16]	10 - 25	<10[20]	40 - 60	10 - 25	<10	10 - 25	10 - 25	<10	25 - 40
	Optimal	125	10 - 25[3]	<10	<10[5]	<10	25 - 40	<10	<10	10 - 25	25 - 40	40 - 60	40 - 60[13]	<10	10 - 25
		190	10 - 25	10 - 25	<10	<10	10 - 25	<10	10 - 25	10 - 25	<10	25 - 40[2]	10 - 25	<10	10 - 25
		275	10 - 25	<10	<10	10 - 25[16]	10 - 25	<10[20]	<10	<10	<10	<10	<10	<10	10 - 25

Category: <10, 10-25, 25-40, 40-60, 60-80, >80

[a] Flow 125 cfs: good cyprinid habitat
[1] high end of range
[1a] probably high end of range
[2] low end of range
[3] Habitat favorable
[4] SL 10 - 25%, BC 25 - 40%, BH < 10%
[5] SW/SL <10%, BC 10 - 25%, BH <10%
[6] BH/SW/TD 60 - 80%; 25 - 40% optimal
[7] excessive velocity
[8] good depth and velocity, unfavorable substrate complexity
[9] poor substrate, uniform sand, juvenilles likely only beneath undercut bank
[10] good habitat
[11] high end of 40 - 60% suitable;low end of 40 - 60% optimal
[12] BH 40 - 60%
[13] SW 40 - 60% for both suitable and optimal
[14] BH/SW <10%
[15] TD/RF next lower category for suitable
[16] velocities too low across most of channel
[17] Substrate conditions improved by presence of small boulders
[18] near 10%
[19] small area of slower velocity along edge affords good habitat; still <10%
[20] very high velocities, poor substrate
[21] severe lack of cover; sandy substrate; low complexity; poor habitat
[22] high velocities; poor substrate; limited cover
[23] extended deliberation: <10% vs 10 - 25%
[24] extended deliberation: <10% vs 10-25%
[25] favorable substrates due to small boulders, but velocity much too high
[26] favorable complexity, velocities - overall quality limited

Russian River/Dry Creek Flow Study

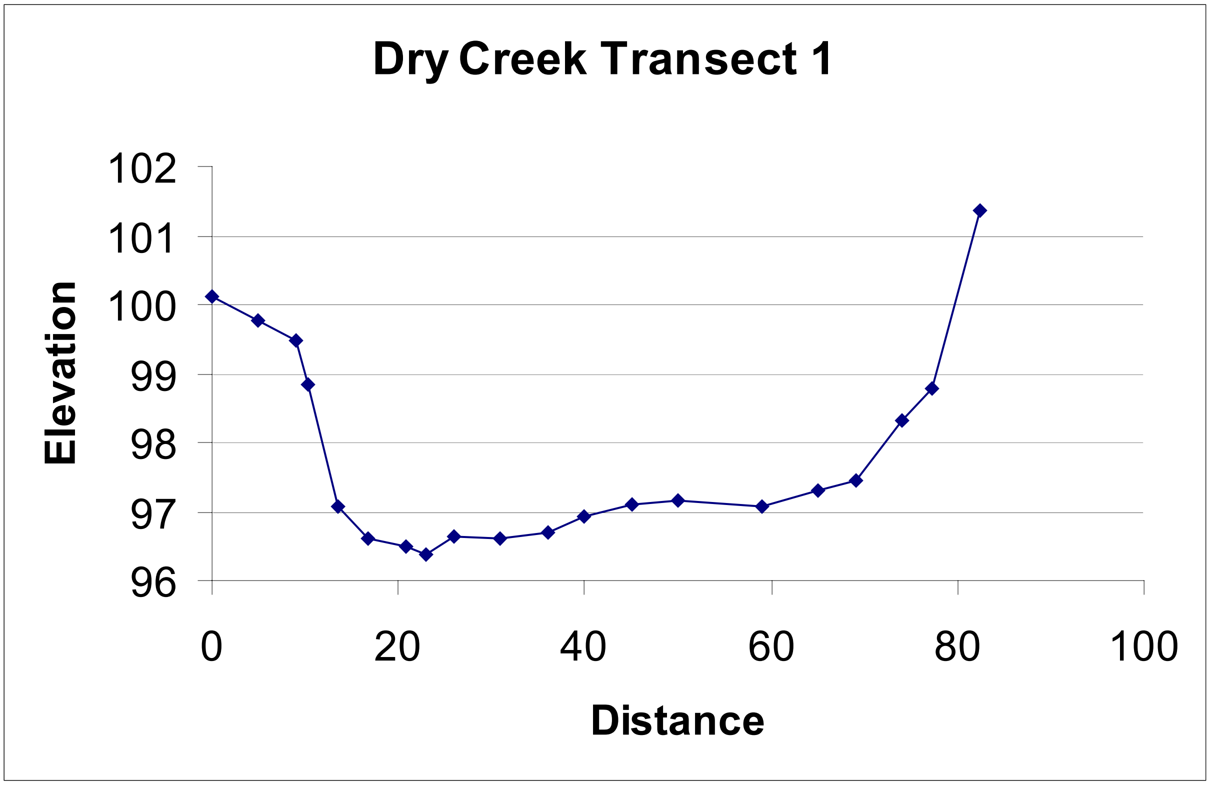
Table 5C. Percent of optimal and suitable habitat spawning by species for Russian River transects at each flow level.

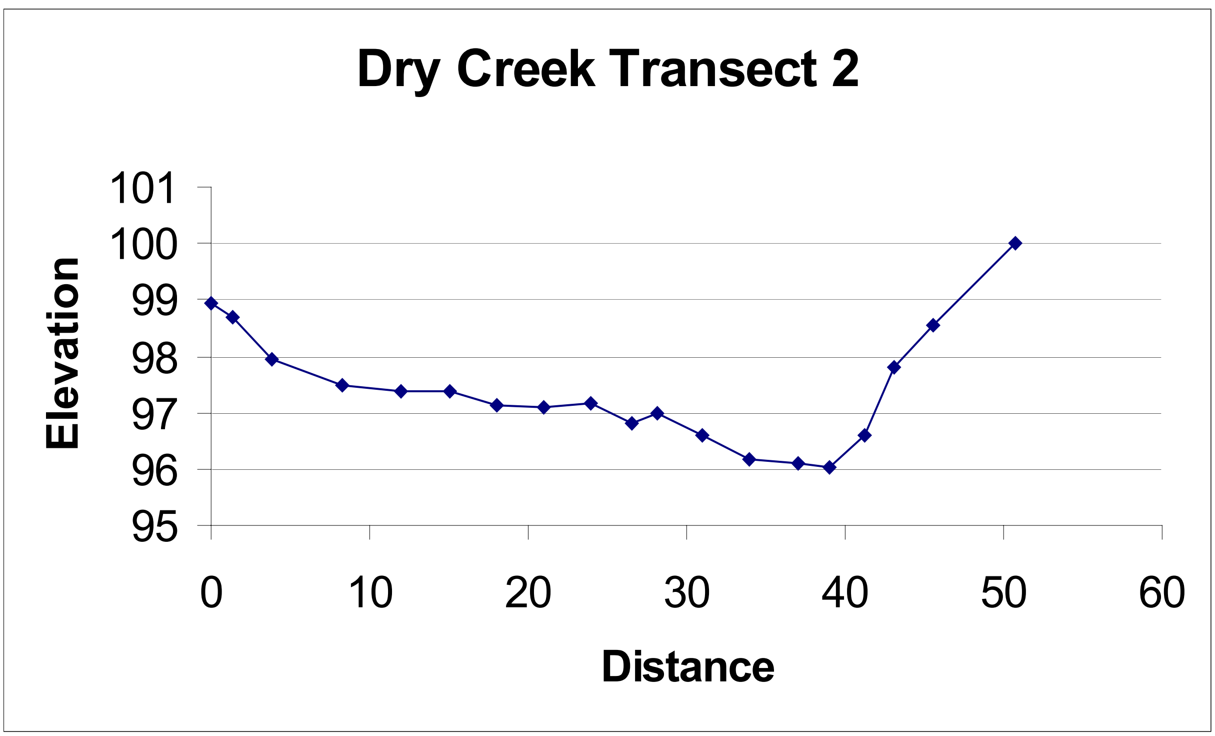
		Flow	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Chinook Spawners	Suitable	125	10 - 25[2,3]	0	25 - 40[2,4]	0	25 - 40[1,5]	10 - 25[7]	<10	0	<10	<10[8]	10 - 25	<10	0
		190	10 - 25	<10	40 - 60	0	40 - 60	25 - 40	<10	0	<10	10 - 25	<10	10 - 25	<10[10]
		275	10 - 25	0	40 - 60	0	25 - 40[2]	10 - 25	0[12]	0[12]	0	<10[13]	10 - 25	10 - 25[14]	<10
	Optimal	125	<10	0	10 - 25[2]	0	10 - 25[1]	<10	0	0	0	<10[8]	<10	<10	0
		190	<10	0	10 - 25	0	25 - 40	10 - 25	0	0	<10	10 - 25	<10	10 - 25	0
		275	<10	0	25 - 40[2]	0	10 - 25	<10[11]	0[12]	0[12]	0	0	<10	<10[14]	0[15]
		Flow	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**
Steelhead Spawners	Suitable	125	10 - 25[1]	0	25 - 40[1]	-	40 - 60[6]	40 - 60	<10	<10	<10	10 - 25	10 - 25	10 - 25	<10
		190	25 - 40[2]	<10	40 - 60	0	40 - 60	40 - 60	<10	0	10 - 25	10 - 25	<10	10 - 25	<10
		275	10 - 25	0	40 - 60	0	25 - 40	10 - 25	0	0	<10	<10	10 - 25	10 - 25	<10
	Optimal	125	10 - 25[2]	0	10 - 25[1]	-	40 - 60[6]	10 - 25	0	0	0	<10	10 - 25	<10	0
		190	10 - 25[2]	0	10 - 25	0	25 - 40	10 - 25	0	0	<10	10 - 25[9]	<10	10 - 25	0
		275	10 - 25	0	10 - 25	0	10 - 25	<10	0	0	0	0	<10	<10	0

[1] High end of range
[2] Low end of range
[3] Good habitat at top of riffle, small substrate somewhat limiting
[4] Good substrate, marginal depths
[5] BH - suitable 40- 60%
[6] Different locations for steelhead vs chinook, but still a large area available
[7] Shallow, but otherwise suitable spawning habitat
[8] Small area of suitable spawning; same area for optimal
[9] More habitat for steelhead than chinook, but still in 10 - 25% range
[10] TT/RF- Next lower category for suitable
[11] Substrate limiting
[12] Sandy substrate, low complexity, poor habitat
[13] Some small areas, debate as to whether it is 10%
[14] Good substrates, but velocity much too high
[15] Poor-Fair hydraulics; too deep, not great substrate

ATTACHMENT D

CROSS SECTIONAL PROFILES AT TRANSECTS


Dry Creek Transect 1
102
101
100
99
98
97
96
Elevation
0
20
40
60
80
100
Distance


Dry Creek Transect 2
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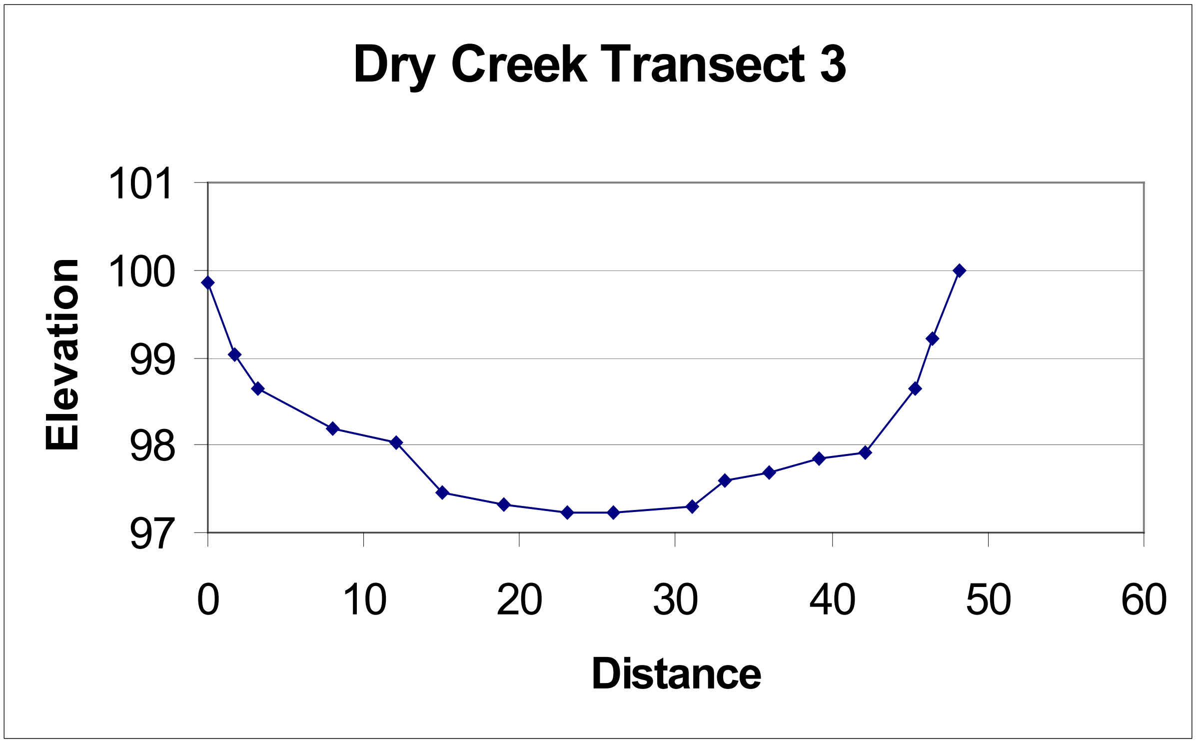
96
95
Elevation
0
10
20
30
40
50
60
Distance


Dry Creek Transect 3
Elevation
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100
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98
97
0
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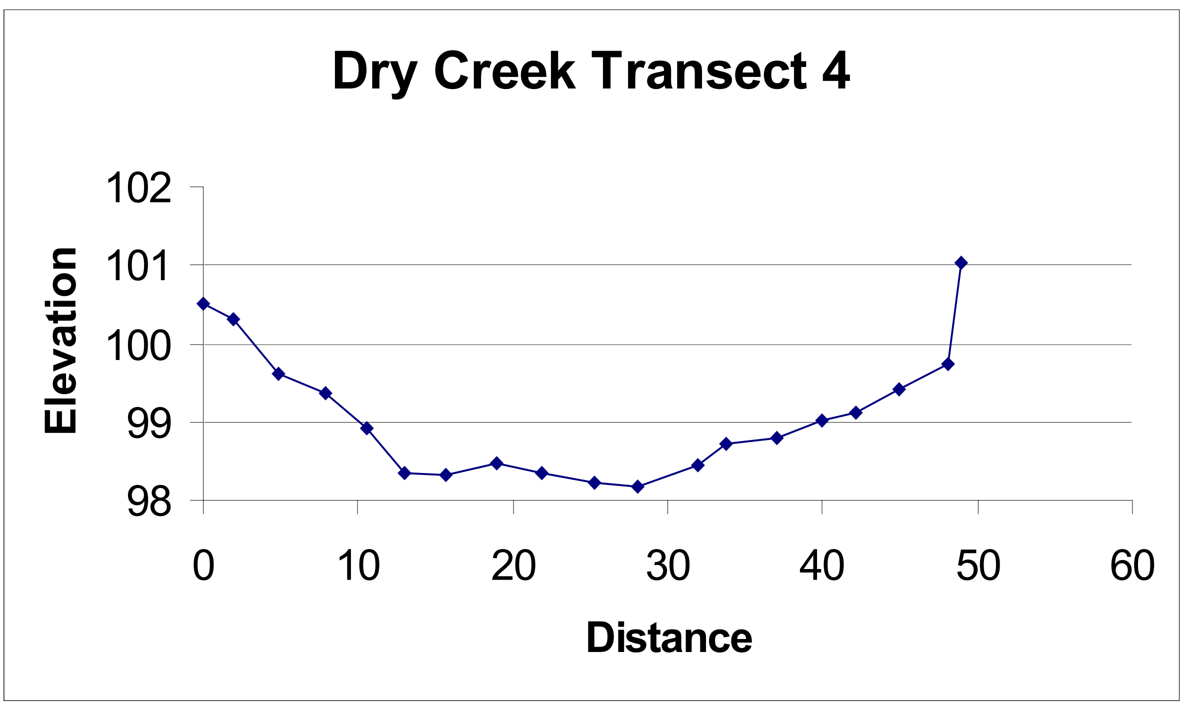
30
40
50
60
Distance


Dry Creek Transect 4
Elevation
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99
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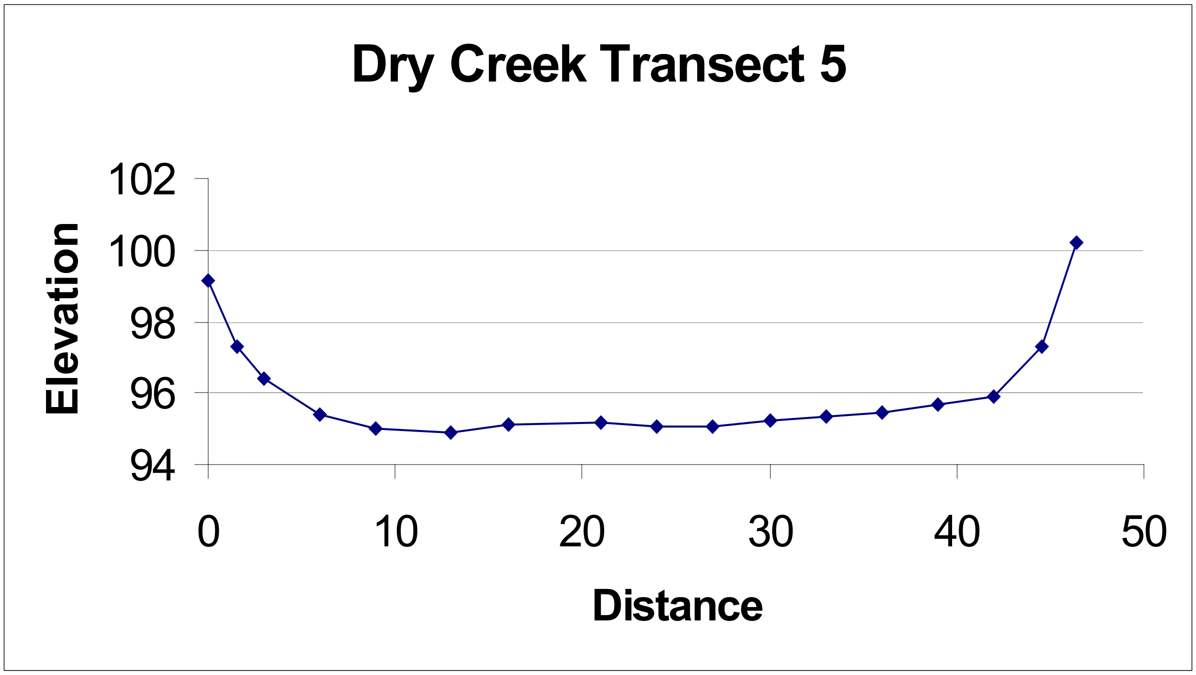
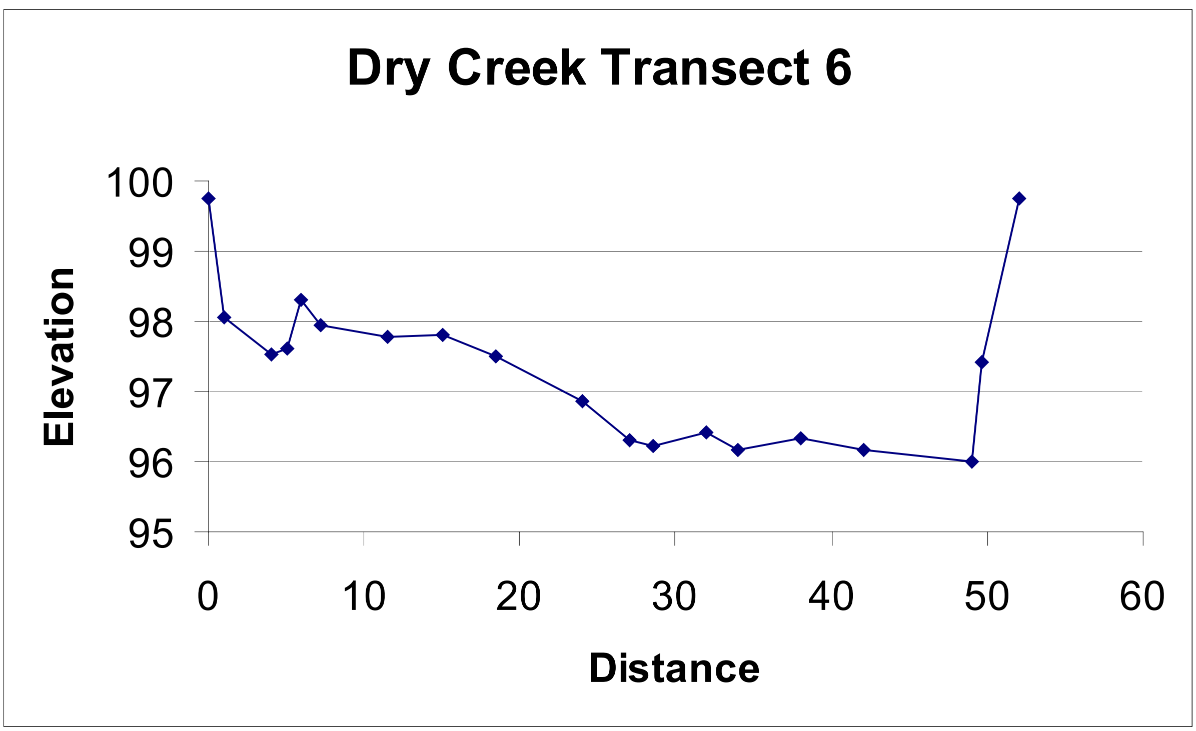
30
40
50
60
Distance


Dry Creek Transect 5
102
100
98
96
94
Elevation
0
10
20
30
40
50
Distance


Dry Creek Transect 6
100
99
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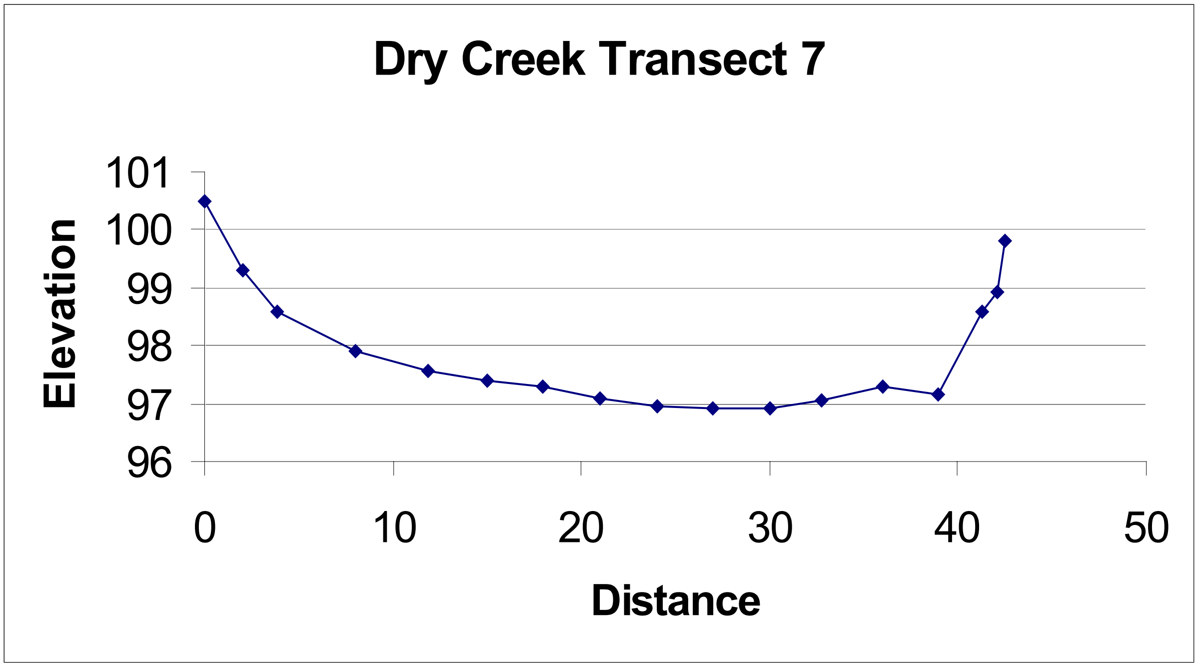
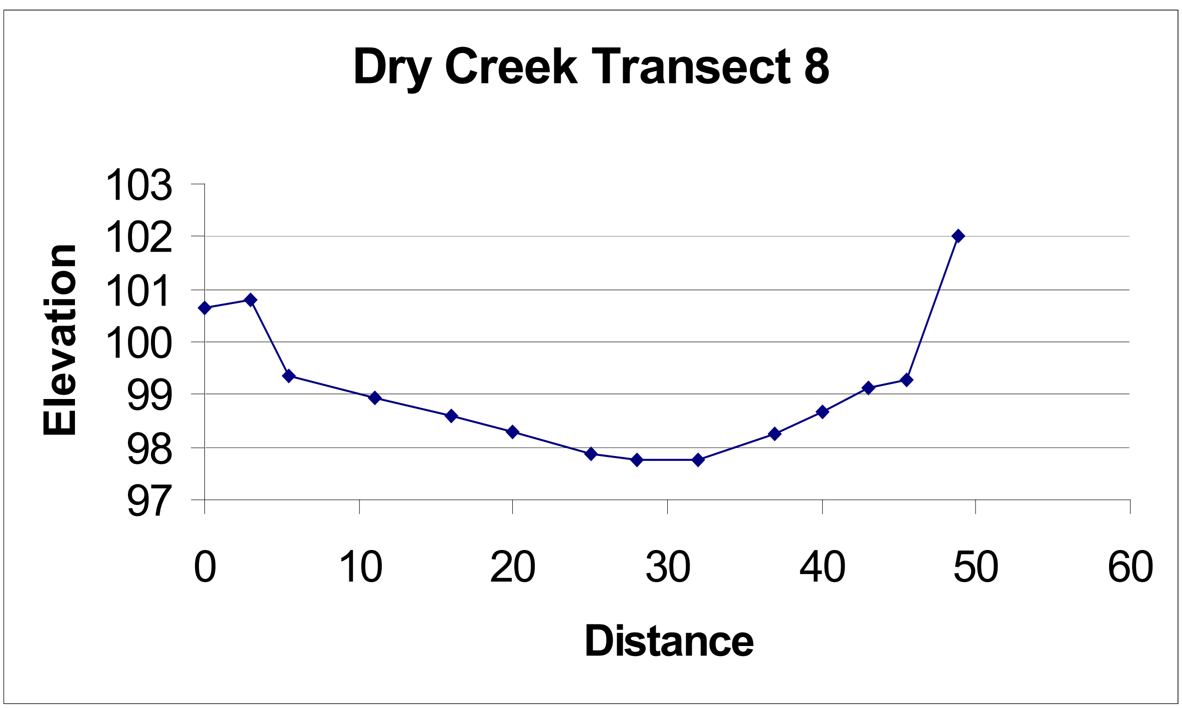
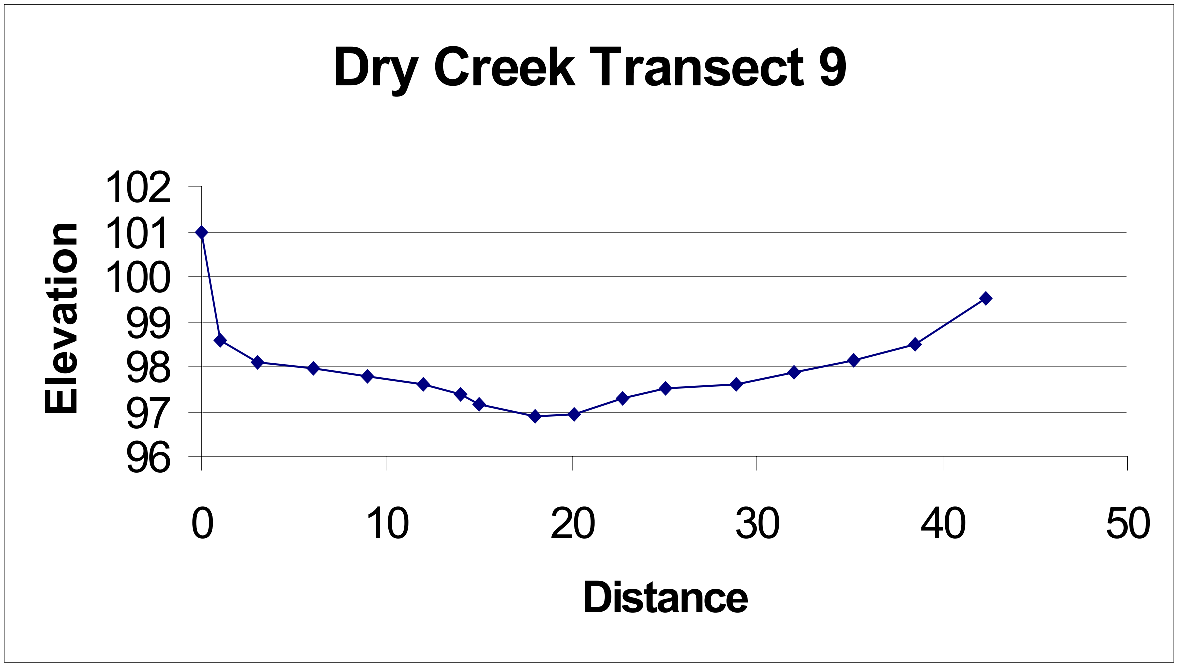
97
96
95
Elevation
0
10
20
30
40
50
60
Distance


Dry Creek Transect 7
Elevation
101
100
99
98
97
96
0
10
20
30
40
50
Distance


Dry Creek Transect 8
Elevation
103
102
101
100
99
98
97
0
10
20
30
40
50
60
Distance


Dry Creek Transect 9
Elevation
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100
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98
97
96
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10
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30
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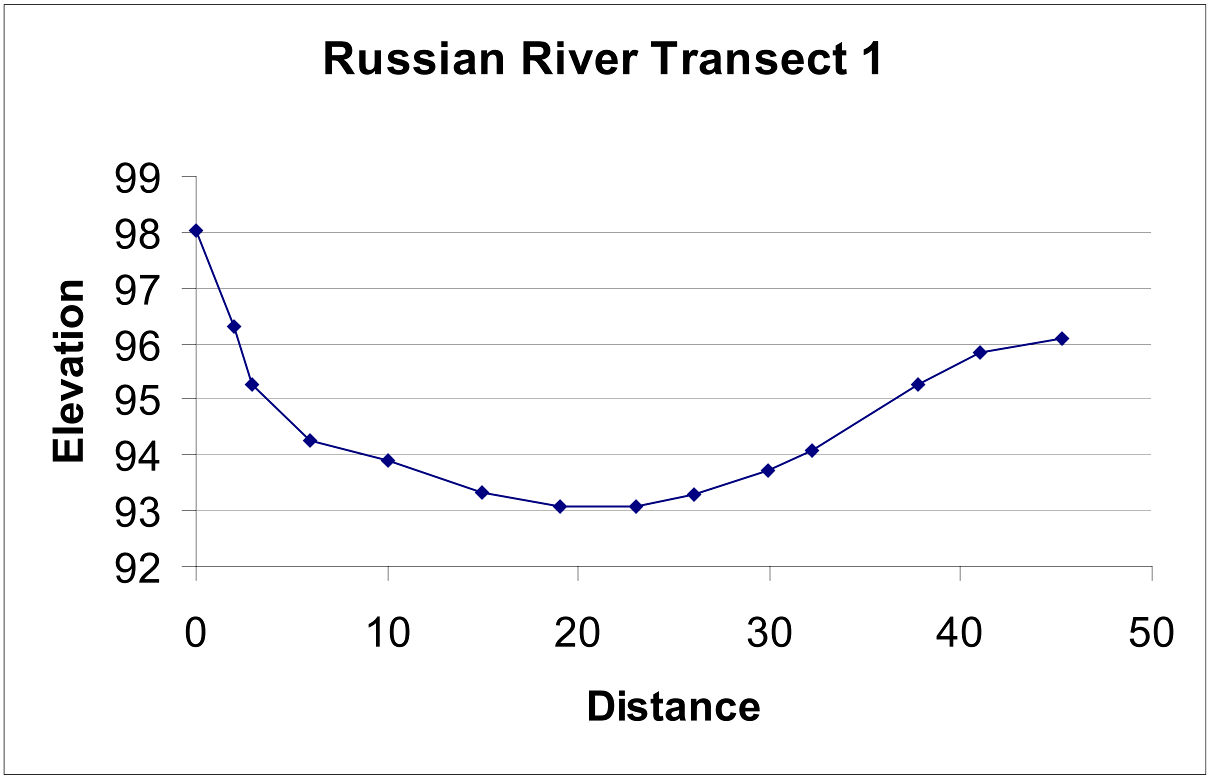
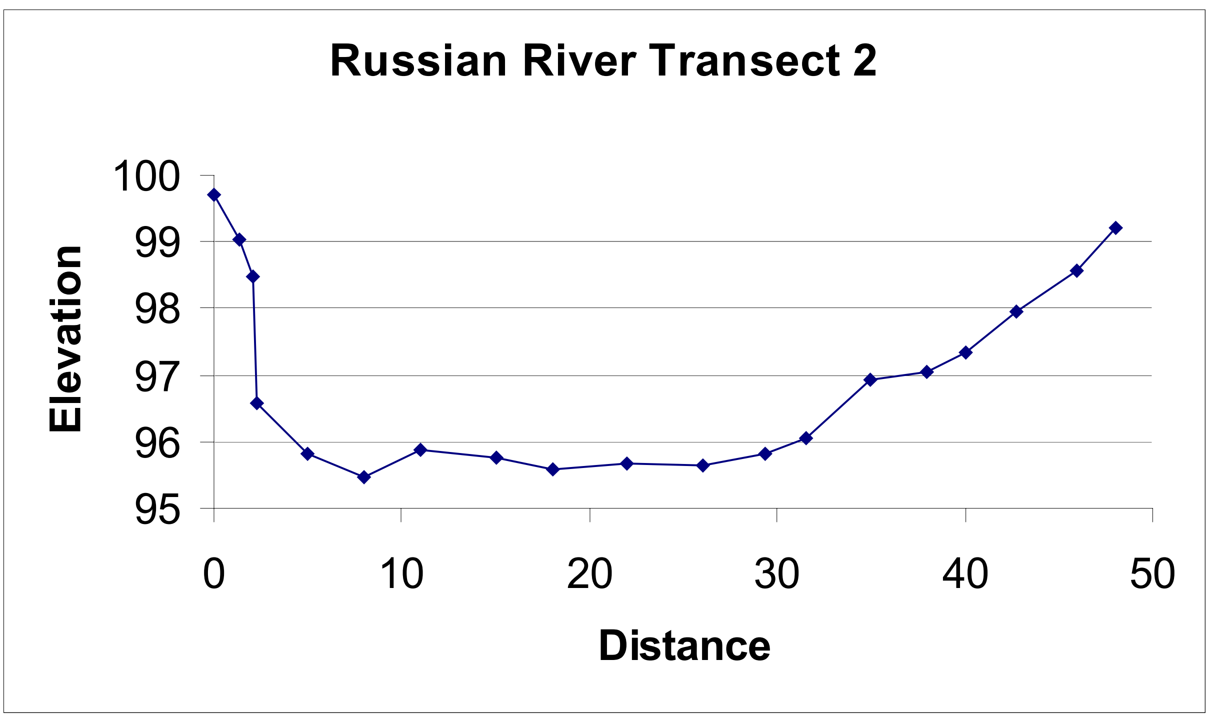
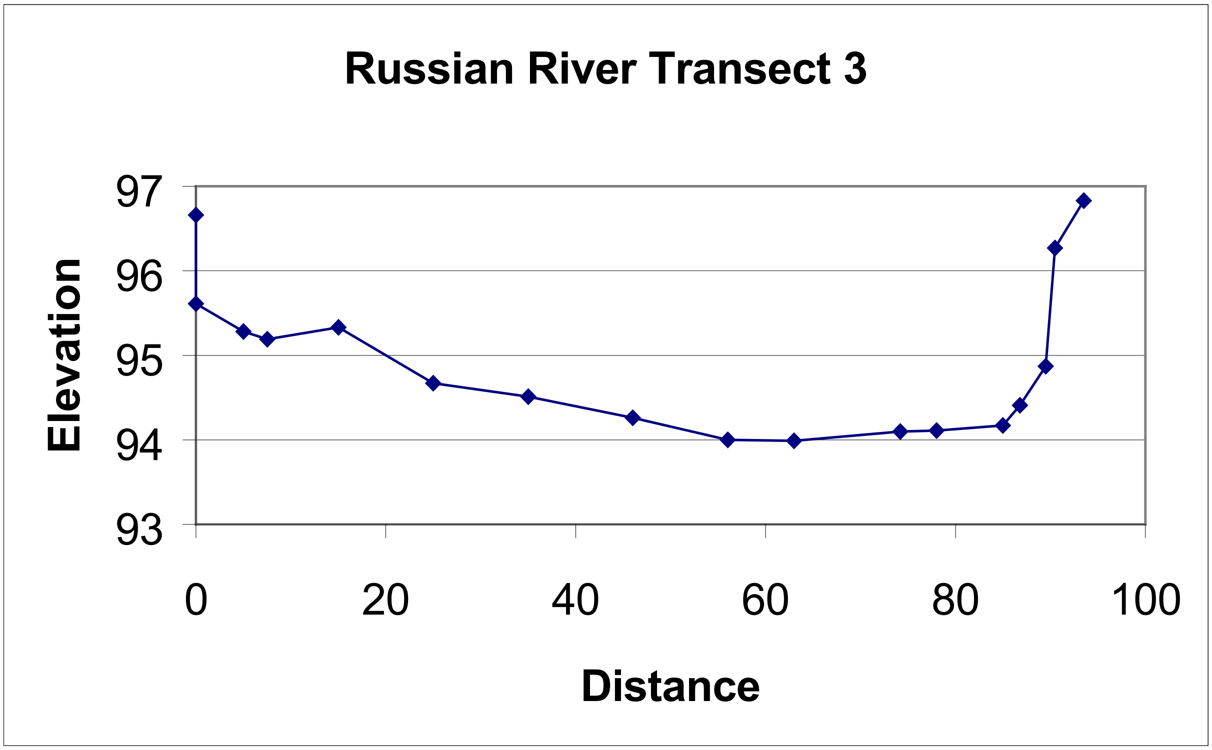
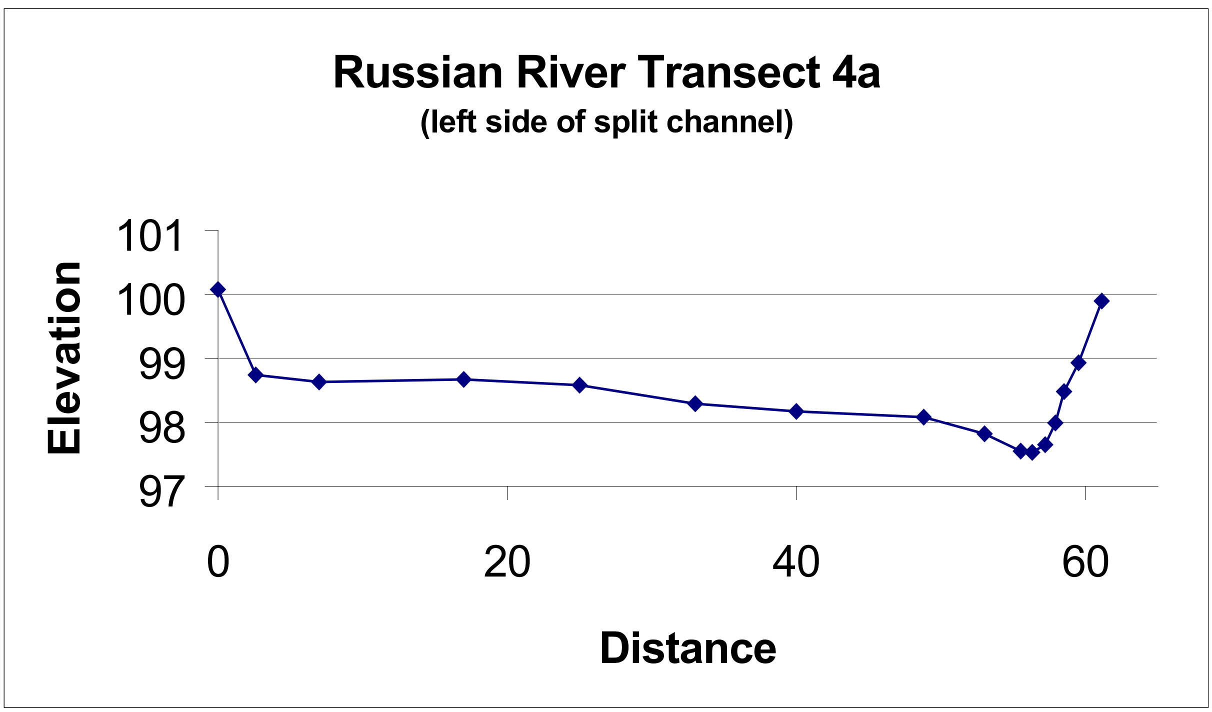
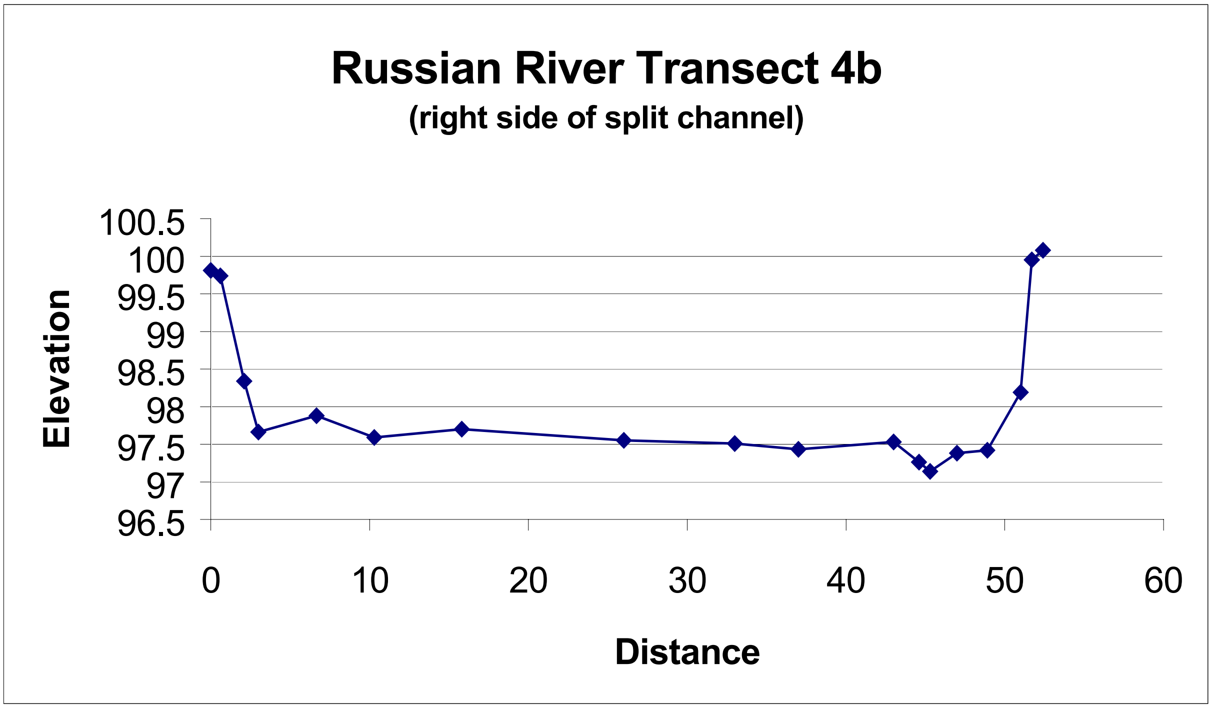
50
Distance

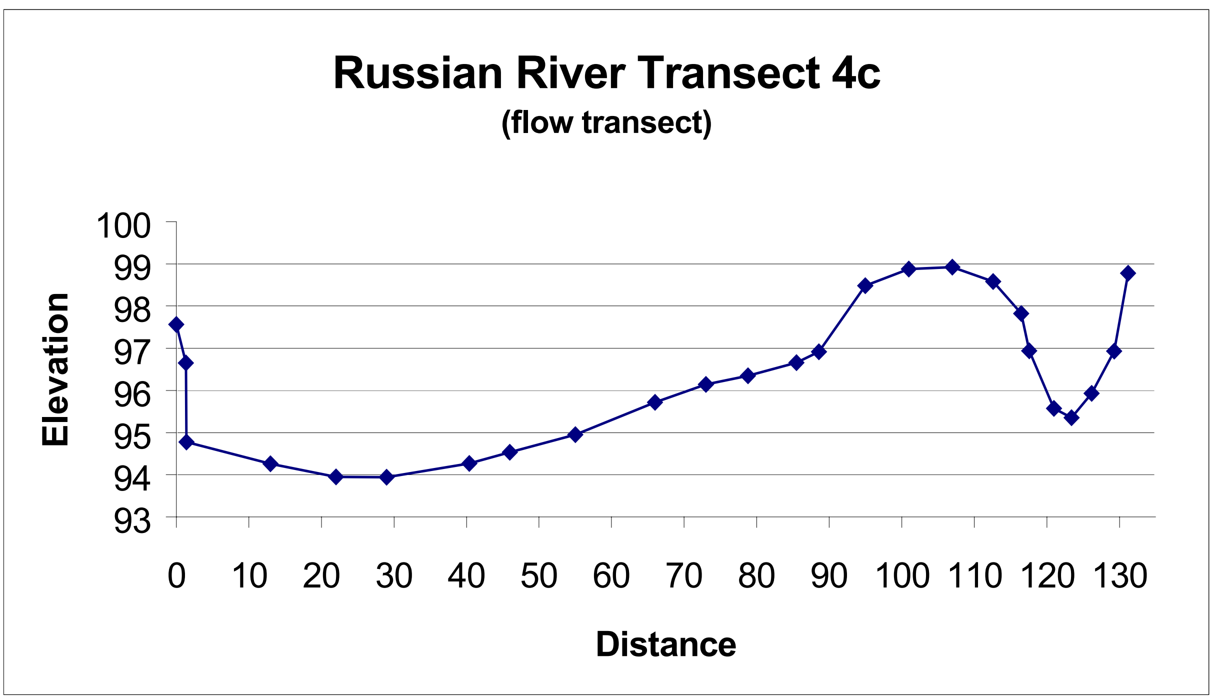

Russian River Transect 1
99
98
97
96
95
94
93
92
Elevation
0
10
20
30
40
50
Distance


Russian River Transect 2
100
99
98
97
96
95
Elevation
0
10
20
30
40
50
Distance


Russian River Transect 3
Elevation
97
96
95
94
93
0
20
40
60
80
100
Distance


Russian River Transect 4a
(left side of split channel)
Elevation
101
100
99
98
97
0
20
40
60
Distance


Russian River Transect 4b
(right side of split channel)
Elevation
100.5
100
99.5
99
98.5
98
97.5
97
96.5
0
10
20
30
40
50
60
Distance


Russian River Transect 4c
(flow transect)
Elevation
100
99
98
97
96
95
94
93
0
10
20
30
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50
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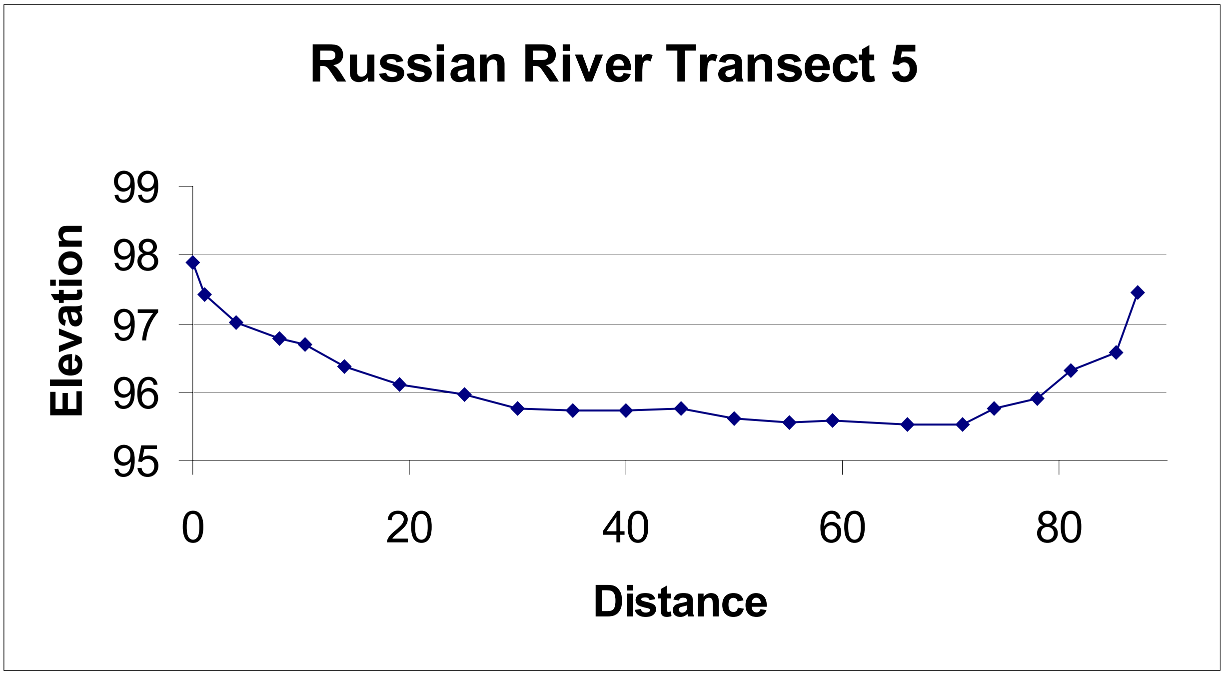
70
80
90
100
110
120
130
Distance


Russian River Transect 5
Elevation
99
98
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40
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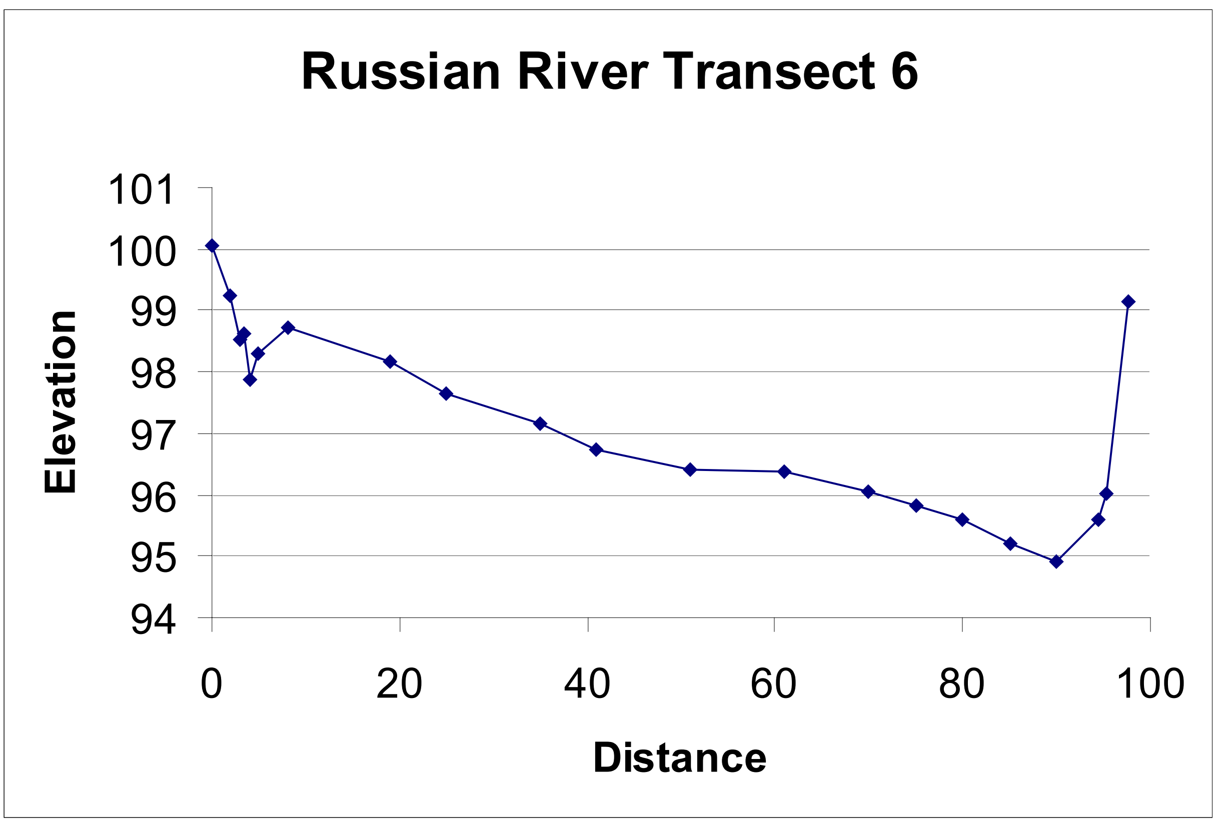
80
Distance


Russian River Transect 6
Elevation
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100
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97
96
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94
0
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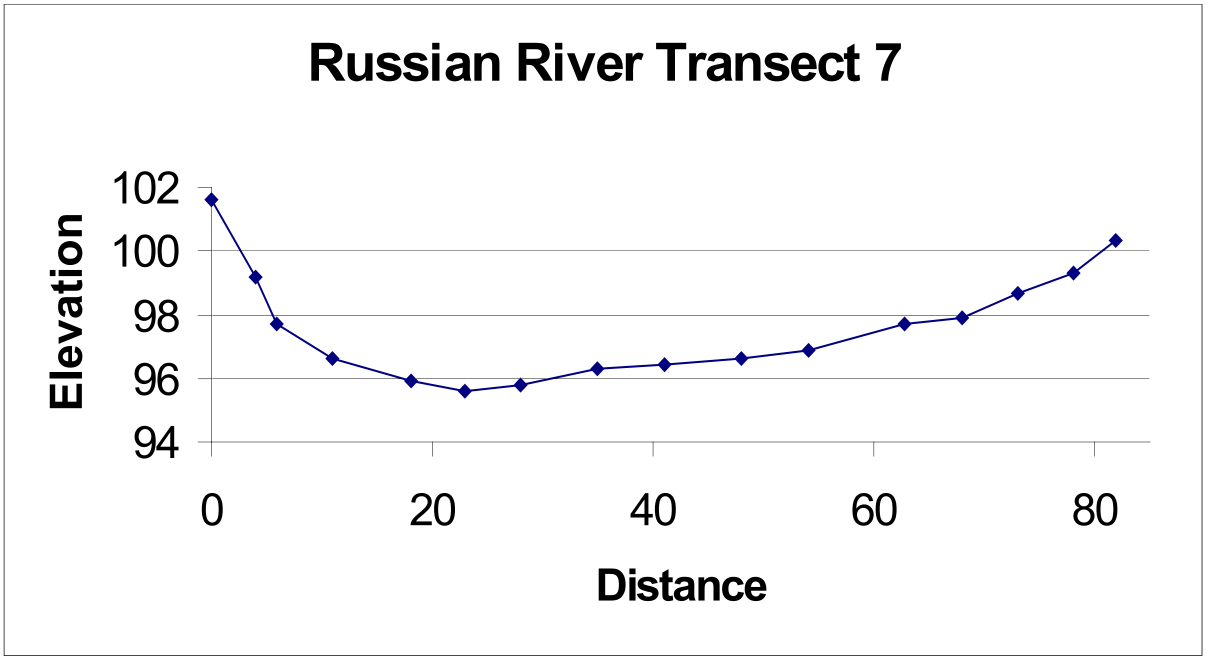
40
60
80
100
Distance


Russian River Transect 7
102
100
98
96
94
Elevation
0
20
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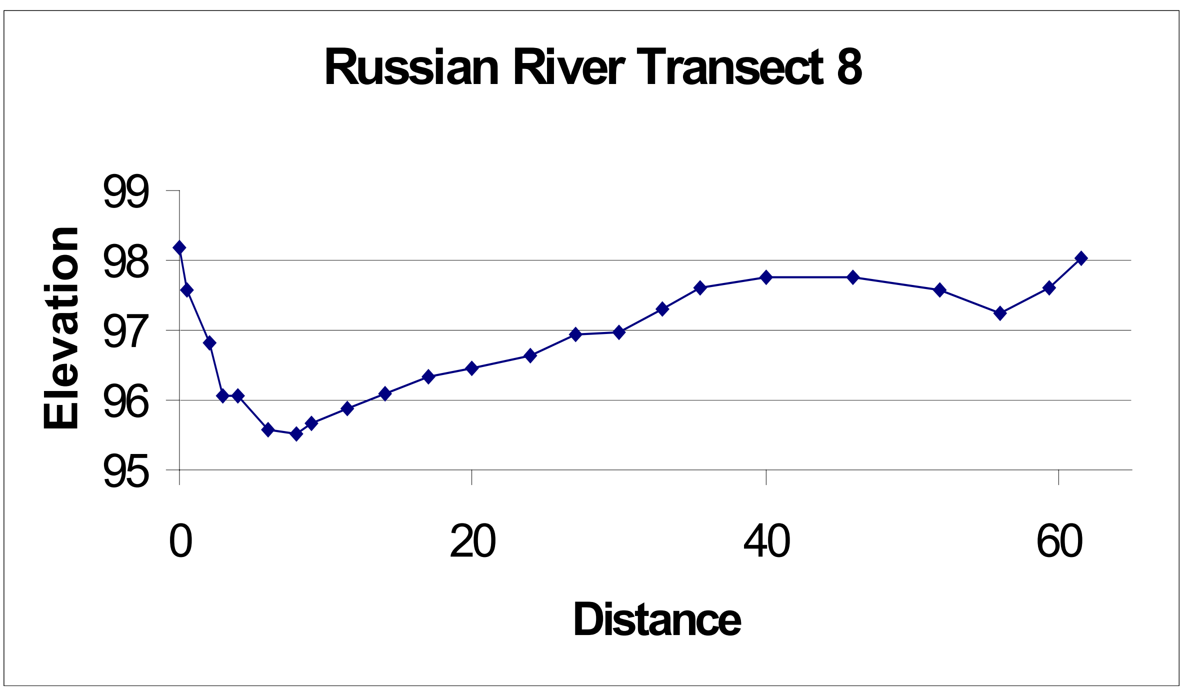
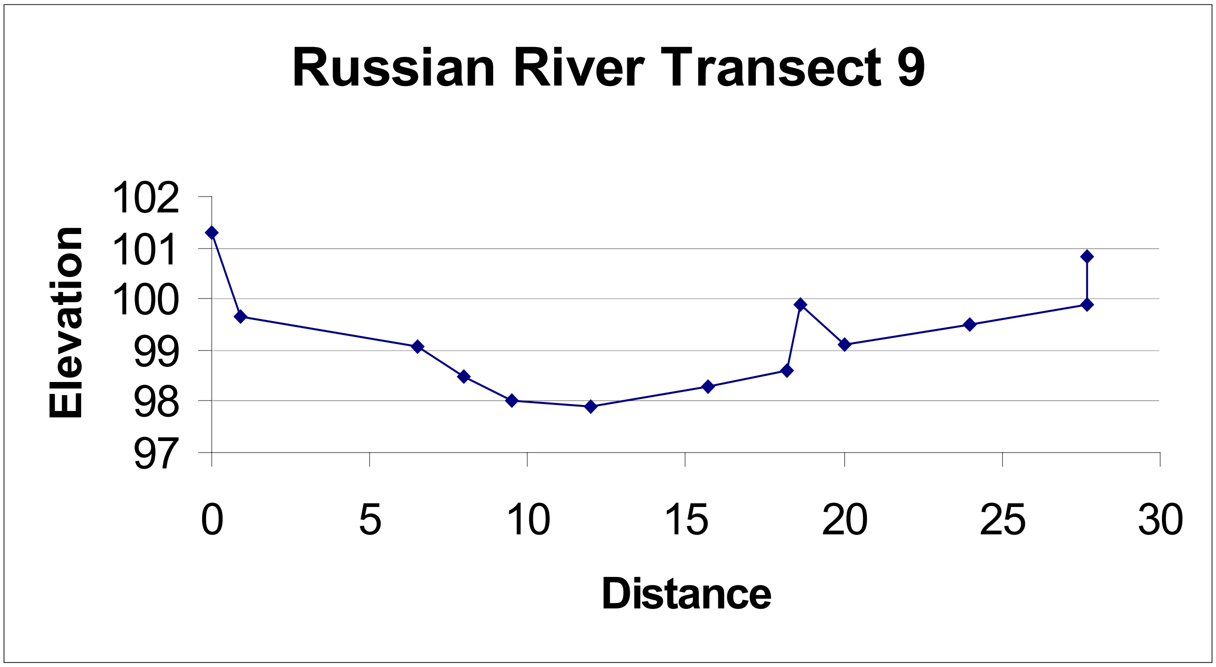
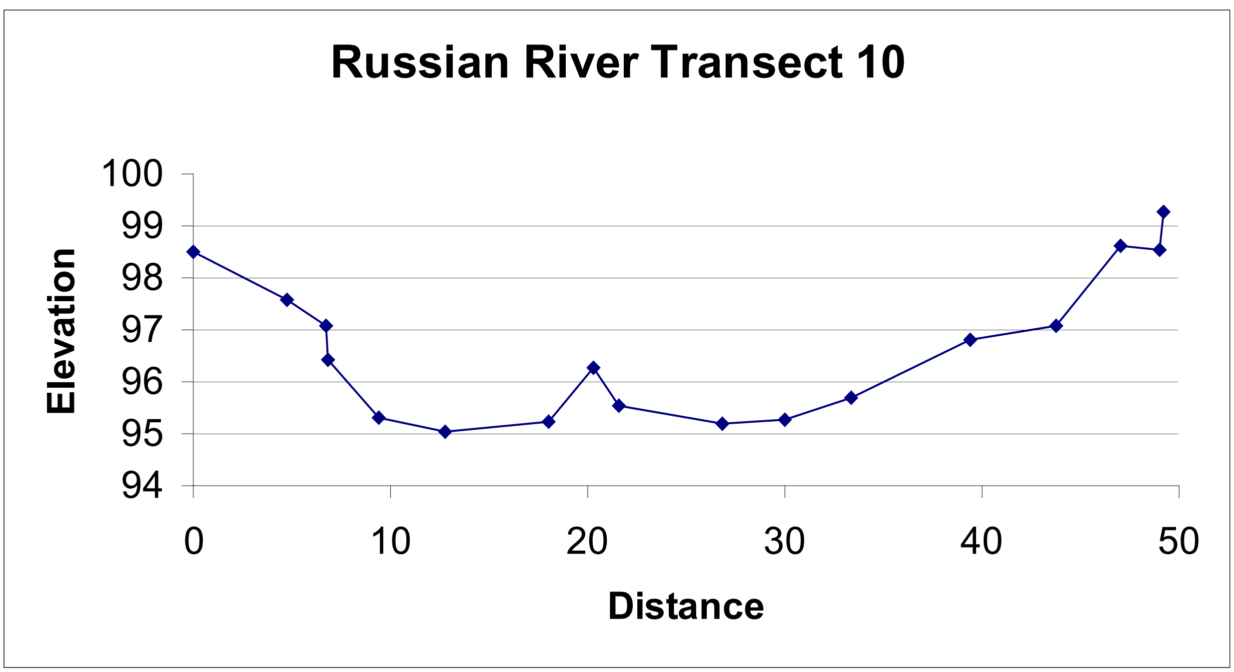
60
80
Distance

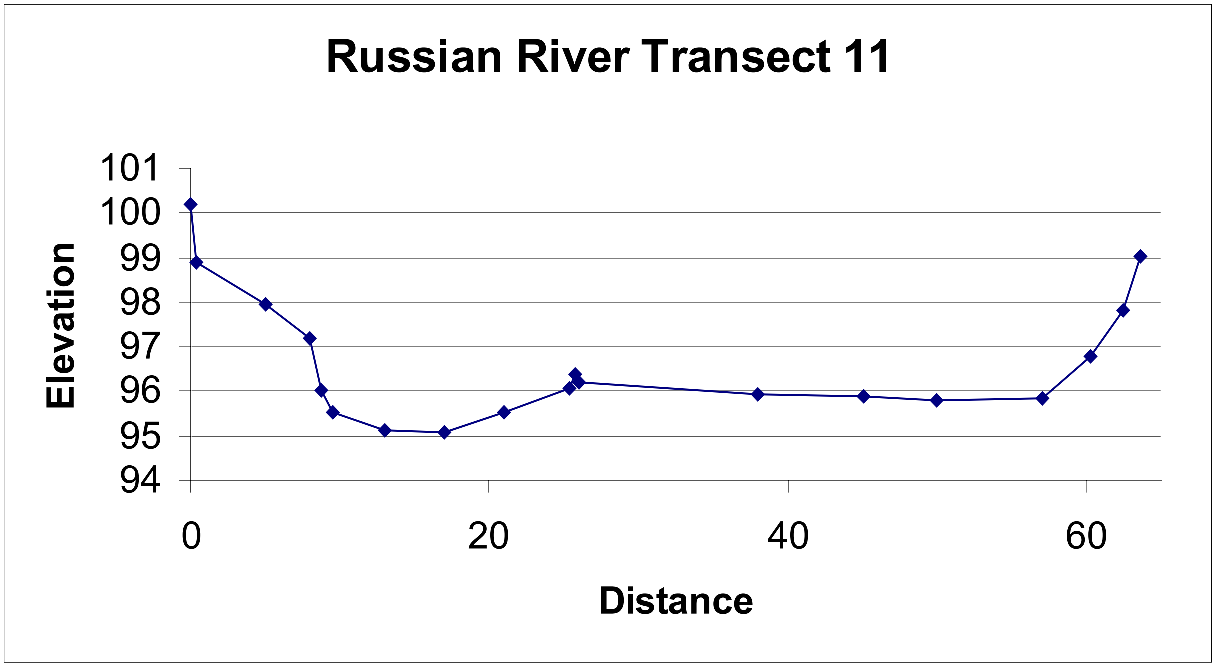

Russian River Transect 8
99
98
97
96
95
Elevation
0
20
40
60
Distance

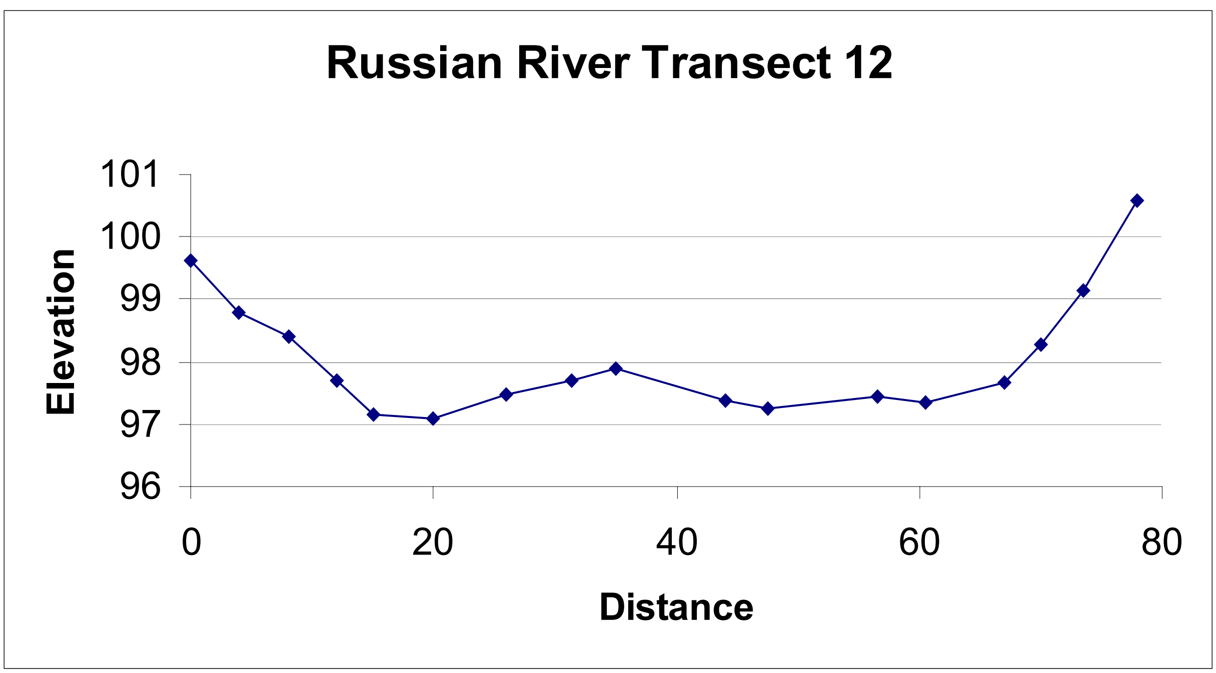


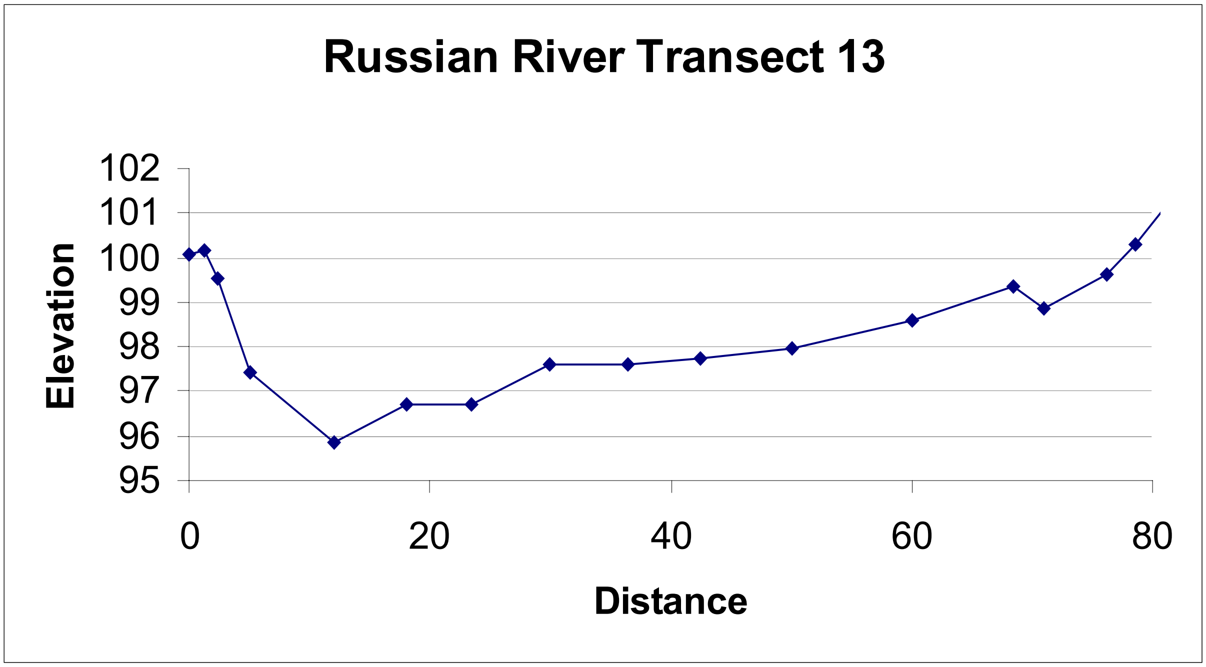
Russian River Transect 9
Elevation
102
101
100
99
98
97
0
5
10
15
20
25
30
Distance



Russian River Transect 10
Elevation
100
99
98
97
96
95
94
0
10
20
30
40
50
Distance


Russian River Transect 11
Elevation
101
100
99
98
97
96
95
94
0
20
40
60
Distance


Russian River Transect 12
Elevation
101
100
99
98
97
96
0
20
40
60
80
Distance


Russian River Transect 13
Elevation
Distance
102
101
100
99
98
97
96
95
0
20
40
60
80

ATTACHMENT E

DEPTHS AND VELOCITIES AT TRANSECTS AND SUMMARY OF HYDRAULIC MEASUREMENTS

Dry Creek Transect 1 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	13.3	1.5	0.27
2	19.5	2.18	0.39
3	26.0	2.1	0.53
4	32.5	1.95	0.62
5	39.0	1.8	0.58
6	45.5	1.55	0.32
7	52.0	1.45	0.2
8	58.5	1.55	0.22
9	65.0	1.45	0.9
10	71.5	0.85	0.01
9/19/01	***Release Flow: 90 cfs***		
1	17.0	2.5	0.57
2	24.0	2.6	0.96
3	31.0	2.45	1.01
4	38.0	2.2	1.00
5	45.0	1.9	0.56
6	52.0	1.8	0.47
7	59.0	2	0.36
8	66.0	1.7	0.08
9	73.0	0.85	0.04
10	80.0	0	0.00

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	16	2.4	0.67
2	23	2.9	1.19
3	30	2.65	1.2
4	37	2.35	1.45
5	44	2.05	1.1
6	51	2.05	0.7
7	58	2.05	0.57
8	65	2.05	0.26
9	72	1.35	0.1
9/21/01	***Release Flow: 150 cfs***		
1	15	2.45	0.85
2	21	2.9	1.30
3	27	2.75	1.47
4	33	2.75	1.27
5	39	2.45	1.44
6	45	2.3	0.89
7	51	2.15	0.57
8	57	2.2	0.56
9	66	2	0.23
10	72	1.4	0.12

Reported velocities are Mean Column Velocities

Dry Creek Transect 2 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	8.0	0.2	0.28
2	11.5	0.35	0.43
3	15.0	0.2	2.21
4	18.5	0.5	0.72
5	22.0	0.4	0.63
6	25.5	0.55	1.27
7	29.0	0.6	1.16
8	32.5	1.1	1.87
9	36.0	1.5	2.72
10	39.5	1.4	1.84
9/19/01	***Release Flow: 90 cfs***		
1	6.0	0.1	0.06
2	10.0	0.4	0.68
3	14.0	0.4	2.76
4	18.0	0.9	1.57
5	22.0	0.65	2.87
6	26.0	0.95	1.68
7	30.0	1.3	2.81
8	34.0	1.8	4.13
9	38.0	1.95	2.26
10	40.0	1.8	2.00

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	5	0.3	0
2	8	0.65	0.29
3	11	0.75	1.35
4	14	0.6	2.79
5	17	1	1.05
6	20	1	3.42
7	23	1.05	1.87
8	26	1.2	2.45
9	29	1.4	3.95
10	32	1.6	5.12
11	35	2.1	3.82
12	38	2.2	2.29
13	41	1.7	1.63
9/21/01	***Release Flow: 150 cfs***		
1	5	0.4	0.01
2	9	0.8	1.71
3	13	0.9	2.4
4	17	1.3	2.04
5	21	1.1	3.02
6	25	1.4	3.14
7	29	1.65	4.05
8	31	1.8	5.86
9	33	2	3.74
10	37	2.3	2.23
11	41	1.8	1.43

Reported velocities are Mean Column Velocities

Dry Creek Transect 2B - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	*Release Flow: 47 cfs*		
1	1.6	0.2	0.01
2	3.2	0.2	0.18
3	4.8	0.35	0.39
4	6.4	0.4	0.72
5	8.0	0.45	0.69
6	9.6	0.8	1.08
7	11.2	1.05	1.28
8	12.8	1.2	1.55
9	14.4	1.1	1.95
10	16.0	1.1	1.69
11	17.6	1.1	1.98
12	19.2	1.05	2.04
13	20.8	0.9	2.08
14	22.4	0.9	2.23
15	24.0	0.7	2.11
16	25.6	0.7	2.51
17	27.2	0.6	1.98
18	28.8	0.6	1.59
19	30.4	0.6	1.3
20	32.0	0.6	1.13
21	33.6	0.5	0.96
22	35.2	0.15	0.54
9/19/01	*Release Flow: 90 cfs*		
1	1	0.15	0.01
2	3	0.4	0.01
3	5	0.55	0.02
4	7	0.7	0.57
5	9	0.8	0.69
6	11	0.85	1.46
7	13	1.05	1.89
8	15	1.25	2.27
9	17	1.45	2.62
10	19	1.25	2.68
11	21	1.3	3.2
12	23	1.15	3.44
13	25	1.05	3.4
14	27	1.1	3.68
15	29	1	3.35
16	31	0.9	3.55
17	33	0.95	2.81
18	35	0.85	2.78
19	37	0.75	2.28
20	39	0.55	1.78
21	41	0.35	1.03
22	43	0.1	0.01

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	*Release Flow: 130 cfs*		
1	2	0.55	0.48
2	4	0.8	0.99
3	6	0.95	1.55
4	8	1	1.58
5	10	1.2	1.74
6	12	1.25	1.95
7	14	1.45	2.37
8	16	1.5	2.83
9	18	1.5	3.13
10	20	1.4	3.4
11	22	1.4	3.61
12	24	1.45	3.78
13	26	1.3	3.78
14	28	1.3	3.77
15	30	1.2	3.78
16	32	1.15	3.32
17	34	1.15	2.9
18	36	1	2.61
19	38	1	2.97
20	40	0.6	1.13
21	42	0.4	0.51
9/21/01	*Release Flow: 150 cfs*		
1	1	0.45	0.01
2	3	0.7	0.86
3	5	0.9	2.11
4	7	1.2	2.31
5	9	1.35	2
6	11	1.45	1.92
7	13	1.45	2.66
8	15	1.35	2.9
9	17	1.7	3.2
10	19	1.7	3.41
11	21	1.6	3.54
12	23	1.6	3.79
13	25	1.6	4.02
14	27	1.45	3.8
15	29	1.45	3.79
16	31	1.3	3.67
17	33	1.3	3.41
18	35	1.25	3.31
19	37	1.2	2.8
20	39	1.2	1.8
21	41	0.85	1.12
22	43	0.7	0.6
23	44	0.25	0.29

Reported velocities are Mean Column Velocities

Dry Creek Transect 3 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	4.4	0.1	0.01
2	6.4	0.2	0.48
3	8.4	0.4	0.46
4	10.4	0.4	0.14
5	12.4	0.6	0.49
6	14.4	1	0.65
7	16.4	1.1	1.2
8	18.4	1.25	1.54
9	20.4	1.2	1.34
10	22.4	1.35	1.68
11	24.4	1.2	1.66
12	26.4	1.25	1.27
13	28.4	1.2	1.15
14	30.4	1.25	1.1
15	32.4	1	1.09
16	34.4	0.8	1.13
17	36.4	0.8	1.37
18	38.4	0.7	1.29
19	40.4	0.75	1.32
20	42.4	0.65	0.88
21	44.4	0.2	0.09
9/19/01	***Release Flow: 90 cfs***		
1	4.4	0.4	0.88
2	6.4	0.35	0.75
3	8.4	0.65	0.65
4	10.4	0.7	0.81
5	12.4	0.9	0.91
6	14.4	1.3	1.35
7	16.4	1.45	2.03
8	18.4	1.55	2.27
9	20.4	1.55	2.1
10	22.4	1.65	2.29
11	24.4	1.6	2.17
12	26.4	1.5	2.07
13	28.4	1.6	1.93
14	30.4	1.65	1.77
15	32.4	1.4	1.98
16	34.4	1.15	1.94
17	36.4	1.15	2.1
18	38.4	1.05	2.01
19	40.4	1.1	1.93
20	42.4	1	1.4
21	44.4	0.5	0.89

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	4.1	0.6	1.02
2	6.1	0.5	1.1
3	8.1	0.9	1.25
4	10.1	0.85	1.29
5	12.1	1	1.26
6	14.1	1.5	1.63
7	16.1	1.6	2.55
8	18.1	1.8	2.85
9	20.1	1.85	2.84
10	22.1	1.9	2.68
11	24.1	1.8	2.81
12	26.1	1.8	2.63
13	28.1	1.8	2.41
14	30.1	1.85	2.21
15	32.1	1.6	2.42
16	34.1	1.4	2.69
17	36.1	1.4	2.46
18	38.1	1.3	2.48
19	40.1	1.3	2.86
20	42.1	1.15	2.15
21	44.1	0.75	1.32
9/21/01	***Release Flow: 150 cfs***		
1	2.6	0.2	0.13
2	4.6	0.75	1.4
3	6.6	0.9	1.87
4	8.6	1.05	1.28
5	10.6	1	1.45
6	12.6	1.15	2
7	14.6	1.75	2.26
8	16.6	1.8	2.89
9	18.6	1.95	3.01
10	20.6	2	2.87
11	22.6	2.05	3.36
12	24.6	2	2.9
13	26.6	1.95	2.73
14	28.6	1.95	2.38
15	30.6	2	2.35
16	32.6	1.75	2.76
17	34.6	1.5	2.75
18	36.6	1.45	2.88
19	38.6	1.4	2.84
20	40.6	1.5	2.87
21	42.6	1.35	2.23
22	44.6	0.9	0.92
23	45.6	0.4	0.24

Reported velocities are Mean Column Velocities

Dry Creek Transect 4 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	12.7	0.8	2.25
2	16.1	0.9	2.08
3	19.5	0.7	2.85
4	22.9	0.9	2.32
5	26.3	1	2.44
6	29.7	1.1	1.61
7	33.1	0.55	0.68
8	36.5	0.35	0.31
9	39.9	0.2	0.29
10	43.3	0	0

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/19/01	***Release Flow: 90 cfs***		
1	8.3	0.2	0.19
2	11.3	0.85	1.67
3	14.3	1.35	2.6
4	17.3	1.15	3.33
5	20.3	1.15	3.59
6	23.3	1.25	3.57
7	26.3	1.4	3.88
8	29.3	1.4	2.29
9	32.3	1.15	2.32
10	35.3	0.8	2.07
11	38.3	0.6	1.54
12	41.3	0.55	0.63
13	44.3	0.2	0.28

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	6.2	0.25	0.66
2	9.2	0.55	1
3	12.2	1.3	2.44
4	15.2	1.4	3.52
5	18.2	1.4	4.27
6	21.2	1.4	3.97
7	24.2	1.5	4
8	27.2	1.7	3.48
9	30.2	1.8	3.03
10	33.2	1.3	3.03
11	36.2	1.1	2.61
12	39.2	0.85	1.84
13	42.2	0.7	1.16
14	45.2	0.45	1.52
15	48.2	0.1	0.01

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/21/01	***Release Flow: 150 cfs***		
1	6.7	0.4	1.04
2	10.7	1.15	2.22
3	14.7	1.75	2.99
4	18.7	1.55	3.94
5	22.7	1.75	3.7
6	26.7	1.85	3.27
7	30.7	1.9	3.35
8	34.7	1.35	3.4
9	38.7	1.05	2.45
10	42.7	0.8	0.71
11	46.7	0.5	0.75

Reported velocities are Mean Column Velocities

Dry Creek Transect 5 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	4	1.55	0.19
2	8	2.1	0.38
3	12	2.4	0.51
4	16	2.05	0.55
5	20	2.1	0.73
6	24	2.1	0.7
7	28	2.1	0.57
8	32	1.95	0.55
9	36	1.8	0.47
10	40	1.6	0.45
9/19/01	***Release Flow: 90 cfs***		
1	4	1.95	0.04
2	8	2.5	0.54
3	12	2.75	0.64
4	16	2.45	0.86
5	20	2.45	1.14
6	24	2.4	1.25
7	28	2.3	1.13
8	32	2.3	0.99
9	36	2.15	0.84
10	40	1.95	0.74
11	43	1.5	0.41

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	5.5	2.45	0.53
2	9.5	2.9	0.72
3	13.5	2.7	0.89
4	17.5	2.8	1.21
5	21.5	2.7	1.50
6	25.5	2.65	1.39
7	29.5	2.6	1.29
8	33.5	2.55	1.15
9	37.5	2.4	1.01
10	41.5	2.2	0.95
9/21/01	***Release Flow: 150 cfs***		
1	3.4	2.2	0.51
2	7.4	2.8	0.84
3	11.4	3.2	1.015
4	15.4	2.9	1.245
5	19.4	2.95	1.67
6	23.4	3	1.78
7	27.4	2.9	1.655
8	31.4	2.6	1.41
9	35.4	2.6	1.24
10	39.4	2.4	0.97
11	43.4	1.6	0.11

Reported velocities are Mean Column Velocities

Dry Creek Transect 6 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	19	0.1	0.01
2	20.5	0.15	0.11
3	22	0.5	0.34
4	23.5	0.7	0.45
5	25	0.8	0.88
6	26.5	1	0.65
7	28	1.2	0.79
8	29.5	1.05	1.19
9	31	1.1	1.16
10	32.5	1	1.07
11	34	1.3	1.25
12	35.5	1.1	1.33
13	37	1.1	1.62
14	38.5	1.2	1.29
15	40	1.2	1.22
16	41.5	1.35	1.65
17	43	1.35	1.53
18	44.5	1.3	1.78
19	46	1.35	1.66
20	47.5	1.3	1.63
21	49	1.3	1.12
22	49.75	0.1	0.01
9/19/01	***Release Flow: 90 cfs***		
1	17.7	0.1	0.01
2	19.4	0.5	0.38
3	21.1	0.7	0.79
4	22.8	0.85	1.18
5	24.5	1.05	1.44
6	26.2	1.25	1.32
7	27.9	1.5	1.76
8	29.6	1.55	2.08
9	31.3	1.35	1.77
10	33	1.55	2.1
11	34.7	1.5	2.05
12	36.4	1.45	2.28
13	38.1	1.4	2.31
14	39.8	1.5	2.31
15	41.5	1.65	2.03
16	42.2	1.6	2.08
17	43.9	1.6	2.41
18	45.6	1.6	2.24
19	47.3	1.8	2.16
20	49	1.65	1.6

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	19	0.6	0.51
2	20.6	0.75	1.63
3	22.2	1.1	1.61
4	23.8	1.2	1.6
5	25.4	1.4	2.02
6	27	1.7	2.49
7	28.6	1.75	1.8
8	30.2	1.75	2.86
9	31.8	1.75	2.51
10	33.4	1.85	2.52
11	35	1.8	2.78
12	36.6	1.7	2.74
13	38.2	1.65	2.71
14	39.8	1.65	2.83
15	41.4	2	2.7
16	43	1.95	2.71
17	44.6	1.9	2.77
18	46.2	1.9	2.67
19	47.8	2	2.56
20	49.4	0.5	1.25
9/21/01	***Release Flow: 150 cfs***		
1	8	0.2	0.59
2	10	0.35	1.1
3	12	0.4	0.82
4	14	0.3	0.31
5	16	0.3	1.18
6	18	0.45	1.11
7	20	0.8	1.75
8	22	1.25	1.97
9	24	1.5	2.04
10	26	1.65	2.21
11	28	1.95	1.91
12	30	1.95	3.37
13	32	1.75	3.02
14	34	2	2.92
15	36	1.85	3.1
16	38	1.95	3.02
17	40	2	2.88
18	42	2.15	2.69
19	44	2	3.38
20	46	2.15	3.06
21	48	2.2	2.81
22	50	0.65	0.77

Reported velocities are Mean Column Velocities

Dry Creek Transect 7 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	*Release Flow: 47 cfs*		
1	5.5	0.3	0.35
2	7.1	0.52	0.48
3	8.7	0.65	0.84
4	10.3	0.8	1.05
5	11.9	1	0.98
6	13.5	1	1.09
7	15.1	1.1	1.27
8	16.7	1.2	1.27
9	18.3	1.25	1.53
10	19.9	1.35	1.24
11	21.5	1.5	1.52
12	23.1	1.6	1.6
13	24.7	1.6	1.4
14	26.3	1.65	1.23
15	27.9	1.65	1.08
16	29.5	1.6	0.85
17	31.1	1.6	0.69
18	32.7	1.5	0.44
19	34.3	1.4	0.28
20	35.9	1.25	0.25
21	37.5	1.4	0.17
22	39.1	1.5	0.03
23	40.7	0.1	0.01
9/19/01	*Release Flow: 90 cfs*		
1	3.9	0.25	0.15
2	5.5	0.55	0.89
3	7.1	0.8	1.05
4	8.7	1	1.33
5	10.3	1.1	1.49
6	11.9	1.35	1.62
7	13.5	1.3	1.77
8	15.1	1.5	1.86
9	16.7	1.55	2.13
10	18.3	1.65	2.28
11	19.9	1.7	2.16
12	21.5	1.85	2.02
13	23.1	1.95	2.18
14	24.7	1.95	1.96
15	26.3	2	1.67
16	27.9	1.9	1.5
17	29.5	1.95	1.22
18	31.1	1.95	0.95
19	32.7	1.8	0.7
20	34.3	1.75	0.62
21	35.9	1.55	0.39
22	37.5	1.7	0.32
23	39.1	1.8	0.17
24	40.7	0.5	0.02

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	*Release Flow: 130 cfs*		
1	3.2	0.3	0.13
2	4.8	0.7	1.09
3	6.4	0.95	1.63
4	8	1.2	1.6
5	9.6	1.35	2.05
6	11.2	1.45	2.09
7	12.8	1.6	2.01
8	14.4	1.75	2.45
9	16	1.8	2.89
10	17.6	1.9	3.04
11	19.2	2.05	3.04
12	20.8	2.1	2.9
13	22.4	2.15	2.9
14	24	2.2	2.67
15	25.6	2.2	2.59
16	27.2	2.25	2.24
17	28.8	2.2	1.79
18	30.4	2.25	1.33
19	32	2.2	1.08
20	33.6	2.05	0.85
21	35.2	1.85	0.59
22	36.8	1.8	0.35
23	38.4	2.1	0.31
24	40	1.7	0.21
25	41.6	0.4	0.08
9/21/01	*Release Flow: 150 cfs*		
1	3	0.4	0.64
2	5	0.95	1.4
3	7	1.25	1.75
4	9	1.45	2.21
5	11	1.6	2.49
6	13	1.8	2.61
7	15	2	3.03
8	17	2.05	3.12
9	19	2.2	3.04
10	21	2.3	2.93
11	23	2.35	2.96
12	25	2.4	2.99
13	27	2.45	2.36
14	29	2.4	2.03
15	31	2.4	1.49
16	33	2.3	1.04
17	35	2	0.65
18	37	2.05	0.39
19	39	2.2	0.27
20	41	0.85	0.19

Reported velocities are Mean Column Velocities

Dry Creek Transect 8 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	7.2	0.2	0.13
2	10.2	0.4	0.23
3	13.2	0.5	0.47
4	16.2	0.75	0.59
5	19.2	0.95	1
6	22.2	1.2	1.38
7	25.2	1.5	1.47
8	28.2	1.6	1.8
9	31.2	1.6	1.5
10	34.2	1.35	0.96
11	37.2	1	1.28
12	40.2	0.6	0.73
13	43.2	0.2	0.14
9/19/01	***Release Flow: 90 cfs***		
1	5.6	0.3	0.1
2	8.6	0.6	0.01
3	11.6	0.75	0.24
4	14.6	0.9	0.9
5	17.6	1.1	1.57
6	20.6	1.4	2.16
7	23.6	1.7	2.18
8	26.6	1.95	2.12
9	29.6	2	2.4
10	32.6	1.8	1.29
11	35.6	1.55	1.35
12	38.6	1.1	1.34
13	41.6	0.7	0.59
14	44.6	0.5	0.27

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	4.1	0.3	0.01
2	5.6	0.6	0.07
3	8.6	0.9	0.93
4	11.6	1.15	1.63
5	14.6	1.35	2.57
6	17.6	2.65	2.4
7	20.6	1.85	2.7
8	23.6	2	2.65
9	26.6	2.3	2.66
10	29.6	2.3	1.98
11	32.6	2.15	1.26
12	35.6	1.8	1.52
13	38.6	1.4	1.4
14	41.6	1	0.81
15	44.6	0.85	0.6
9/21/01	***Release Flow: 150 cfs***		
1	4	0.5	0.44
2	8	1.5	1.47
3	12	1.35	2.59
4	16	1.55	2.25
5	20	2	2.89
6	24	2.35	2.65
7	28	2.55	2.52
8	32	2.4	1.39
9	36	1.95	1.59
10	40	1.55	1.06
11	44	1.05	0.74

Reported velocities are Mean Column Velocities

Dry Creek Transect 9 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/13/01	***Release Flow: 47 cfs***		
1	3.75	0.1	0.01
2	5.25	0.1	0.01
3	6.75	0.2	0.25
4	8.25	0.2	0.36
5	9.75	0.35	1.9
6	11.25	0.55	2.11
7	12.75	0.7	2.72
8	14.25	0.85	2.9
9	15.75	1.05	3
10	17.25	1.25	3.03
11	18.75	1.25	3.1
12	20.25	1.2	3.44
13	21.75	1.1	2.73
14	23.25	0.85	2.76
15	24.75	0.55	2.26
16	26.25	0.5	2.49
17	27.75	0.5	1.96
18	29.25	0.45	1.99
19	30.75	0.3	1.29
20	32.25	0.2	0.59
21	33.75	0.05	0.01
9/19/01	***Release Flow: 90 cfs***		
1	2.4	0.2	0.11
2	4.2	0.35	0.09
3	6	0.4	0.37
4	7.8	0.5	0.43
5	9.6	0.6	1.15
6	11.4	0.8	3.66
7	13.2	1	2.66
8	15	1.3	3.01
9	16.8	1.45	3.18
10	18.6	1.5	3.41
11	20.4	1.5	3.6
12	22.2	1.2	3.34
13	24	1	3.15
14	25.8	0.85	2.9
15	27.6	0.8	2.84
16	29.4	0.8	2.31
17	31.2	0.55	2.1
18	33	0.4	1.51
19	34.8	0.25	0.38
20	36.6	0.1	0.01
21	38.4	0.1	0.01
22	40.2	0.1	0.01
23	42	0.1	0.01

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/20/01	***Release Flow: 130 cfs***		
1	2.5	0.6	0.54
2	4	0.6	0.46
3	5.5	0.7	0.4
4	7	0.8	0.83
5	8.5	0.85	0.68
6	10	1	1.47
7	11.5	1.2	2.58
8	13	1.3	2.65
9	14.5	1.5	3.16
10	16	1.65	3.47
11	17.5	1.8	3.56
12	19	1.85	3.91
13	20.5	1.85	3.76
14	22	1.7	3.67
15	23.5	1.4	3.59
16	25	1.2	3.62
17	26.5	1.1	3.5
18	28	1.1	3.26
19	29.5	1.05	3.21
20	31	0.9	3.03
21	32.5	0.8	2.91
22	34	0.7	2.41
23	35.5	0.55	1.98
24	37	0.4	1.58
25	38.5	0.3	0.46
9/21/01	***Release Flow: 150 cfs***		
1	2.5	0.8	0.33
2	4.3	0.85	0.8
3	6.1	1	0.22
4	7.9	1.05	0.84
5	9.7	1.2	1.17
6	11.5	1.35	2.74
7	13.3	1.55	3.09
8	15.1	1.9	3.63
9	16.9	2.05	3.89
10	18.7	2.25	3.96
11	20.5	2.1	4.06
12	22.3	1.95	3.89
13	24.1	1.8	3.55
14	25.9	1.4	3.27
15	27.7	1.4	3.66
16	29.5	1.4	3.57
17	31.3	1.2	3.73
18	33.1	1.05	3.51
19	34.9	0.9	3
20	36.7	0.65	2.59
21	38.5	0.4	0.27

Reported velocities are Mean Column Velocities

Russian River Transect 1 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	4	0.4	0.2
2	6.5	1	0.2
3	9	1.3	1.7
4	11.5	1.4	2.14
5	14	1.75	4.2
6	16.5	1.9	3.69
7	19	2	3.65
8	21.5	2.15	3.19
9	24	2	2.88
10	26.5	1.75	1.7
11	29	1.4	0.8
12	31.5	1.2	0.06
13	34	0.6	0.08
14	36.5	0.15	0.01
10/1/01	***Release Flow: 190 cfs***		
1	4.3	1	0.25
2	7.8	1.55	2.21
3	11.3	1.85	3.39
4	14.8	2.2	3.6
5	18.3	2.4	5.25
6	21.8	2.25	3.97
7	25.3	2.3	2.94
8	28.8	1.9	2.29
9	32.3	1.4	1.29
10	35.8	0.75	0.22
11	39.3	0.01	0.01
10/4/01	***Release Flow: 275 cfs***		
1	4	1.3	0.90
2	8	2.1	3.14
3	12	2.4	4.39
4	16	2.6	4.93
5	20	2.9	5.61
6	24	2.8	3.70
7	28	2.3	3.27
8	32	1.9	1.91
9	36	1.1	0.84
10	40	0.25	0.01

Reported velocities are Mean Column Velocities

Russian River Transect 2 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	3.4	2.15	0.01
2	5.4	2.7	0.01
3	7.4	2.95	0.01
4	9.4	2.9	0.2
5	11.4	2.5	0.52
6	13.4	2.45	0.69
7	15.4	2.8	0.835
8	17.4	2.95	1.32
9	19.4	2.85	1.71
10	21.4	2.85	1.72
11	23.4	2.8	1.755
12	25.4	2.8	1.745
13	27.4	2.75	1.71
14	29.4	2.6	1.73
15	31.4	2.4	1.46
16	33.4	2.05	1.67
17	35.4	1.75	1.67
18	37.4	1.6	1.29
19	39.4	1.05	1.14
20	41.4	0.7	0.49
21	43.4	0.4	0.02
10/1/01	***Release Flow: 190 cfs***		
1	3.8	2.5	0.01
2	7.8	3.4	0.01
3	11.8	2.8	1.25
4	15.8	3.2	1.36
5	19.8	3.25	2.35
6	23.8	3.2	2.58
7	27.8	3.2	2.62
8	31.8	2.7	2.30
9	35.8	2.05	2.26
10	39.8	1.4	1.96
11	43.8	0.7	0.32

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	***Release Flow: 275 cfs***		
1	3	2.7	0.015
2	7	3.5	0.025
3	11	3.2	1.04
4	15	3.4	1.32
5	19	3.5	3.225
6	23	3.5	3.42
7	27	3.5	3.455
8	31	3.1	3.27
9	35	2.25	3.56
10	39	1.95	2.78
11	43	1.15	2.67
12	47	0.1	0.01

Reported velocities are Mean Column Velocities

Russian River Transect 3 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	10.1	0.1	0.01
2	14.1	0.1	0.34
3	18.1	0.3	0.68
4	22.1	0.3	0.96
5	26.1	0.4	0.97
6	30.1	0.5	1.61
7	34.1	0.55	1.44
8	38.1	0.65	1.75
9	42.1	0.65	1.8
10	46.1	0.75	2.29
11	50.1	0.95	2.1
12	54.1	1	2.21
13	58.1	1.1	2.54
14	62.1	1.05	2.65
15	66.1	0.95	2.45
16	70.1	0.95	2.5
17	74.1	0.95	2.57
18	78.1	0.95	2.81
19	82.1	0.85	2.59
20	86.1	0.7	0.49
10/1/01	***Release Flow: 190 cfs***		
1	6.5	0.2	0.17
2	10.5	0.35	0.85
3	14.5	0.45	1.22
4	18.5	0.65	1.13
5	22.5	0.65	1.73
6	26.5	0.8	1.87
7	30.5	0.85	1.96
8	34.5	1	2.04
9	38.5	1	2.67
10	42.5	1	2.5
11	46.5	1.1	2.44
12	50.5	1.2	2.54
13	54.5	1.45	2.54
14	58.5	1.45	2.91
15	62.5	1.4	3.06
16	66.5	1.3	3.13
17	70.5	1.3	3.08
18	74.5	1.3	3.15
19	78.5	1.3	3.21
20	82.5	1.2	2.61
21	86.5	0.9	0.1

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	***Release Flow: 275 cfs***		
1	6	0.4	0.32
2	10	0.6	1.09
3	14	0.7	1.04
4	18	0.85	1.51
5	22	0.9	2.04
6	26	1	2.17
7	30	1.05	2.48
8	34	1.15	2.59
9	38	1.25	2.76
10	42	1.25	2.9
11	46	1.35	2.91
12	50	1.5	2.92
13	54	1.65	2.92
14	58	1.75	3.27
15	62	1.65	3.58
16	66	1.5	3.38
17	70	1.55	3.37
18	74	1.6	3.51
19	78	1.5	3.47
20	82	1.5	2.95
21	86	1.2	0.14

Reported velocities are Mean Column Velocities

Russian River Transect 4 - measured depths and velocities at observed release flows

4A

Station	(feet)	(feet)	(fps)
9/26/01	***Release Flow: 125 cfs***		
1	5	0.15	0.07
2	12	0.1	0.48
3	16	0.1	0.07
4	20	0.15	1.13
5	24	0.25	1.67
6	28	0.3	2.55
7	32	0.6	3.55
8	36	0.7	2.97
9	40	0.65	3.72
10	44	0.75	2.89
11	48	0.75	2.2
12	52	0.9	2.48
13	56	1.3	0.67
10/1/01	***Release Flow: 190 cfs***		
1	5	0.45	0.29
2	10	0.3	1.34
3	15	0.3	0.87
4	20	0.3	1.62
5	25	0.45	3.53
6	30	0.65	4.23
7	35	0.8	4.23
8	40	0.9	4.02
9	45	1	3.96
10	50	0.85	3.97
11	55	1.4	1.74
10/4/01	***Release Flow: 275 cfs***		
1	5	0.7	0.37
2	10	0.4	2.8
3	15	0.4	1.36
4	20	0.4	2.59
5	25	0.45	4.48
6	30	0.6	5.59
7	35	0.8	4.76
8	40	1.05	4.48
9	45	0.9	4.57
10	50	1.1	3.53
11	55	1.5	2.75

4B

Station	(feet)	(feet)	(fps)
9/26/01	***Release Flow: 125 cfs***		
1	3	0.55	0.15
2	7	0.25	1.86
3	11	0.55	1.97
4	15	0.4	1.99
5	19	0.55	0.69
6	23	0.55	1.99
7	27	0.65	1.69
8	31	0.55	1.79
9	35	0.6	1.93
10	39	0.6	1.5
11	43	0.6	1.05
12	45.5	0.9	0.05
13	49	0.55	0.24
10/1/01	***Release Flow: 190 cfs***		
1	4	0.6	0.24
2	8	0.7	2.71
3	12	0.7	3.22
4	16	0.7	3.01
5	20	0.7	2.79
6	24	0.8	2.32
7	28	0.8	2.73
8	32	0.85	2.68
9	36	1	2.65
10	40	0.75	2.6
11	44	1	1.92
12	48	0.9	0.25
10/4/01	***Release Flow: 275 cfs***		
1	6	0.85	2.76
2	10	1	3.32
3	14	0.8	4.28
4	18	0.9	3.76
5	22	1	3.61
6	26	1	2.86
7	30	1.05	3.05
8	34	0.95	3.29
9	38	1.1	3.19
10	42	1	3.04
11	46	1.2	0.04
12	50	0.75	0.42

Reported velocities are Mean Column Velocities

Russian River Transect 4C - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	*Release Flow: 125 cfs*		
1	2	0.8	0.02
2	5	2.3	0.22
3	8	2.7	0.195
4	11	2.85	0.205
5	14	2.9	0.295
6	17	3	0.335
7	20	2.9	0.62
8	23	2.7	0.99
9	26	2.6	1.185
10	29	2.45	1.27
11	32	2.4	0.95
12	35	2.3	0.9
13	38	2.2	1
14	41	2	0.89
15	44	1.9	0.77
16	47	1.65	0.65
17	50	1.6	0.5
18	53	1.35	0.48
19	56	1.3	0.37
20	59	1	0.36
21	62	0.9	0.31
22	65	0.55	0.21
23	68	0.4	0.17
24	71	0.3	0.12
25	74	0.2	0.01

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/1/01	*Release Flow: 190 cfs*		
1	3.3	2.35	0.37
2	7.3	2.2	0.42
3	11.3	2.3	0.4
4	15.3	2.4	0.62
5	19.3	2.7	1.015
6	23.3	2.7	1.365
7	27.3	2.7	1.66
8	31.3	2.7	1.765
9	35.3	2.55	1.645
10	39.3	2.45	1.55
11	43.3	2.35	1.36
12	47.3	2.15	1.23
13	51.3	1.85	1.12
14	55.3	1.7	0.92
15	59.3	1.5	0.96
16	63.3	1	0.85
17	67.3	0.8	0.75
18	71.3	0.7	0.6
19	75.3	0.4	0.44
20	79.3	0.25	0.25

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	*Release Flow: 275 cfs*		
1	3.1	1.9	0.54
2	7.1	2.3	0.52
3	11.1	2.3	0.36
4	15.1	2.6	0.42
5	19.1	2.7	1.305
6	23.1	2.9	1.805
7	27.1	2.9	2.035
8	31.1	2.9	2.17
9	35.1	2.75	2.02
10	39.1	2.6	1.835
11	43.1	2.55	1.725
12	47.1	2.3	1.51
13	51.1	2.05	1.3
14	55.1	1.9	1.16
15	59.1	1.65	1.06
16	63.1	1.3	1.09
17	67.1	0.9	1.01
18	71.1	0.8	0.81
19	75.1	0.55	0.78
20	79.1	0.5	0.6
21	83.1	0.3	0.19

SIDE CHANNEL

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
1	4	0.6	0.08
2	6	0.95	0.87
3	8	1.2	0.88
4	10	0.85	0.63

SIDE CHANNEL

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
21	119.6	0.9	0.83
22	121.6	1.4	1.48
23	123.6	0.5	2.03
24	125.6	1.2	0.26
25	127.6	0.45	0.01

SIDE CHANNEL

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
22	118.7	0.65	0.09
23	120.7	1.3	2.07
24	122.7	1.7	2.17
25	124.7	1.6	1.32
26	126.7	0.95	0.06
27	128.7	0.4	0.04

Reported velocities are Mean Column Velocities

Russian River Transect 5 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	14	0.2	0.04
2	20	0.5	1.1
3	26	0.7	1.59
4	32	0.9	1.43
5	38	1	1.62
6	44	0.95	1.49
7	50	1	1.84
8	56	1.1	1.75
9	62	1.1	1.89
10	68	1.15	2.13
11	74	0.8	2.36
12	80	0.35	1.75
10/1/01	***Release Flow: 190 cfs***		
1	10	0.2	0.01
2	18	0.8	1.56
3	26	1.1	2.03
4	34	1.25	1.97
5	42	1.25	2.27
6	50	1.3	2.54
7	58	1.35	2.36
8	66	1.4	2.48
9	74	1.2	2.83
10	82	0.45	2.41
10/4/01	***Release Flow: 275 cfs***		
1	8	0.35	0.22
2	16	0.8	2.26
3	24	1.2	2.5
4	32	1.25	2.62
5	40	1.35	2.74
6	48	1.35	2.7
7	56	1.5	2.92
8	64	1.5	2.72
9	72	1.35	2.98
10	80	0.85	2.86

Reported velocities are Mean Column Velocities

Russian River Transect 6 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	*Release Flow: 125 cfs*		
1	30.5	0.2	0.01
2	33.5	0.4	0.01
3	36.5	0.5	0.01
4	39.5	0.8	0.17
5	42.5	0.9	0.86
6	45.5	0.95	1.2
7	48.5	1.1	0.59
8	51.5	1.15	0.04
9	54.5	1.25	0.06
10	57.5	1.2	0.23
11	60.5	1.2	0.2
12	63.5	1.2	0.28
13	66.5	1.3	0.04
14	69.5	1.5	0.6
15	72.5	1.65	1.17
16	75.5	1.8	1.57
17	78.5	1.9	1.65
18	81.5	2.15	2.1
19	84.5	2.4	2.37
20	87.5	2.65	2.165
21	90.5	2.7	1.495
22	93.5	2.05	0.66
23	95	1.9	0.4
10/1/01	*Release Flow: 190 cfs*		
1	21.1	0.25	0.06
2	24.9	0.4	0.05
3	28.7	0.65	0.01
4	32.5	0.7	0.09
5	36.3	0.95	0.04
6	40.1	1.3	0.31
7	43.9	0.45	0.79
8	47.7	1.6	1.28
9	51.5	1.65	0.83
10	55.3	1.7	0.51
11	59.1	1.65	0.43
12	62.9	1.7	0.56
13	66.7	1.8	0.96
14	70.5	2.1	1.52
15	74.3	2.25	2.08
16	78.1	2.4	2.42
17	81.9	2.7	2.42
18	85.7	3	2.45
19	89.5	3.2	2.17
20	93.3	2.5	0.76
21	94.3	2.45	0.20

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	*Release Flow: 275 cfs*		
1	21	0.55	0.01
2	24.5	0.7	0.02
3	28	0.95	0.02
4	31.5	1.1	0.01
5	35	1.2	0.04
6	38.5	1.5	0.24
7	42	1.7	0.92
8	45.5	1.7	1.21
9	49	1.95	1.39
10	52.5	2.05	1.21
11	56	2	1.04
12	59.5	2	1.09
13	63	2.1	1.15
14	66.5	2.2	1.56
15	70	2.4	1.92
16	73.5	2.6	2.27
17	77	2.7	2.365
18	80.5	2.85	2.45
19	84	3.1	2.7
20	87.5	3.5	2.685
21	91	3.4	1.5
22	94.5	2.7	0.215

Reported velocities are Mean Column Velocities

Russian River Transect 7 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	8	0.45	0.42
2	10.5	1.05	1.09
3	13	1.15	0.93
4	15.5	1.35	0.81
5	18	1.65	1.16
6	20.5	1.9	1.92
7	23	1.9	1.84
8	25.5	1.85	1.77
9	28	1.75	1.67
10	30.5	1.6	1.79
11	33	1.4	1.79
12	35.5	1.35	1.93
13	38	1.35	1.92
14	40.5	1.2	1.92
15	43	1.1	1.69
16	45.5	1	1.62
17	48	0.85	1.6
18	50.5	0.85	1.5
19	53	0.65	1.43
20	55.5	0.6	1.21
21	58	0.35	0.72
22	60.5	0.1	0.01
10/1/01	***Release Flow: 190 cfs***		
1	7.5	0.95	0.1
2	10	1.6	0.99
3	12.5	1.7	0.87
4	15	1.95	0.73
5	17.5	2.2	1.15
6	20	2.45	1.83
7	22.5	2.55	1.71
8	25	2.5	2.015
9	27.5	2.4	2.27
10	30	2.35	2.35
11	32.5	2.1	2.12
12	35	2	2.17
13	37.5	1.95	2.2
14	40	1.75	2
15	42.5	1.7	2
16	45	1.65	2.24
17	47.5	1.55	2.07
18	50	1.45	1.78
19	52.5	1.3	1.99
20	55	1.2	1.63
21	57.5	1	1.48
22	60	0.7	1.02
23	62.5	0.45	0.6
24	65	0.3	0.56
25	67.5	0.3	0.45

Reported velocities are Mean Column Velocities

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	***Release Flow: 275 cfs***		
1	6	0.8	0.36
2	9	1.7	0.75
3	12	1.9	1.12
4	15	2.25	0.86
5	18	2.5	1.13
6	21	2.75	1.835
7	24	2.9	1.69
8	27	2.7	2.385
9	30	2.55	2.39
10	33	2.35	2.51
11	36	2.2	2.5
12	39	2.15	2.26
13	42	2	2.45
14	45	1.9	2.42
15	48	1.8	2.03
16	51	1.65	2.2
17	54	1.5	1.84
18	57	1.25	1.69
19	60	1	1.38
20	63	0.7	1.12
21	66	0.65	0.49
22	69	0.4	0.12

Russian River Transect 8 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	*Release Flow: 125 cfs*		
1	3.5	1.45	1.85
2	6.5	1.7	2.54
3	9.5	1.8	3.36
4	12.5	1.6	3.97
5	15.5	1.4	3.82
6	18.5	1.2	3.44
7	21.5	0.8	2.73
8	24.5	0.65	2.64
9	27.5	0.6	2.05
10	30.5	0.4	0.89
11	33.5	0.1	0.01
10/1/01	*Release Flow: 190 cfs*		
1	3	1.95	0.84
2	8	2.35	3.74
3	13	2.05	5.02
4	18	1.75	4.68
5	23	1.2	4.27
6	28	0.95	3.5
7	33	0.55	2.02
8	38	0.2	0.01
9	43	0.1	0.01
10	48	0.2	0.01
11	53	0.45	0.01
12	56	0.6	0.3
13	58	0.55	0.01
10/4/01	*Release Flow: 275 cfs*		
1	2	1.8	0.59
2	6	2.6	1.865
3	10	2.55	3.58
4	14	2.2	4.9
5	18	2.05	5.06
6	22	1.65	4.6
7	26	1.35	3.94
8	30	1.2	3.49
9	34	0.8	2.17
10	38	0.5	0.21
11	42	0.35	0.5
12	46	0.5	0.06
13	50	0.6	0.05
14	54	0.8	0.68
15	58	0.85	1.05
16	62	0.1	0.01

Reported velocities are Mean Column Velocities

Russian River Transect 9 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	8.6	0.5	0.81
2	9.6	0.3	1.21
3	10.6	0.5	0.89
4	11.6	0.65	1.64
5	12.6	0.4	1.07
6	13.6	0.4	1.85
7	14.6	0.3	3.07
8	15.6	0.2	1.53
9	16.6	0.2	0.19
10	17.6	0.1	0.01
10/1/01	***Release Flow: 190 cfs***		
1	8.4	0.3	0.42
2	9.4	0.65	2.08
3	10.4	0.6	1.9
4	11.4	0.85	1.97
5	12.4	0.8	2.25
6	13.4	0.65	1.49
7	14.4	0.5	3.85
8	15.4	0.35	3.36
9	16.4	0.2	1.79
10	17.4	0.3	0.35
10/4/01	***Release Flow: 275 cfs***		
1	8	0.3	0.1
2	9	0.7	1.19
3	10	0.6	3.12
4	11	0.6	2.4
5	12	0.8	3.12
6	13	0.6	3.8
7	14	0.7	3.51
8	15	0.5	3.15
9	16	0.35	3.28
10	17	0.4	2.02
11	18	0.35	2.28

Reported velocities are Mean Column Velocities

Russian River Transect 10 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	8.3	1.15	1.09
2	11.8	2.1	0.12
3	15.3	1.85	2.8
4	18.8	1.05	3.74
5	22.3	1.6	2.15
6	25.8	1.75	2.19
7	29.3	1.7	2.21
8	32.8	1.3	1.87
9	36.3	0.85	1.59
10	39.8	0.2	0.78
10/1/01	***Release Flow: 190 cfs***		
1	6.8	1	0.65
2	10.3	2.6	0.515
3	13.8	2.35	1.68
4	17.3	2.15	3.75
5	20.8	1.9	0.65
6	24.3	2.2	3.59
7	27.8	2.2	3.44
8	31.3	1.85	2.44
9	34.8	1.4	2.24
10	38.3	0.85	1.68
11	41.8	0.6	0.87
10/4/01	***Release Flow: 275 cfs***		
1	6.5	1.15	1.54
2	10	2.7	0.63
3	13.5	2.45	2.25
4	17	2.35	4.34
5	20.5	2	1.15
6	24	2.35	3.88
7	27.5	2.45	3.45
8	31	2.15	2.48
9	34.5	1.7	2.94
10	38	1.1	1.99
11	41.5	0.75	1.1
12	44	0.2	0.47

Reported velocities are Mean Column Velocities

Russian River Transect 11 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	11.4	1.65	1.3
2	16.4	1.8	3.17
3	21.4	1.55	2.83
4	26.4	0.9	1.74
5	31.4	0.25	1.41
6	36.4	0.5	2.67
7	41.4	0.75	0.96
8	46.4	0.65	1.84
9	51.4	0.8	1.98
10	56.4	0.8	0.08
10/1/01	***Release Flow: 190 cfs***		
1	10.3	1.9	0.08
2	15.3	1.65	3.63
3	20.3	1.5	3.24
4	25.3	1.2	1.75
5	30.3	0.65	1.64
6	35.3	1	1.98
7	40.3	1.35	1.34
8	45.3	1.3	2.81
9	50.3	1.45	2.92
10	55.3	1.5	1.52
11	60.3	0.4	0.04
10/4/01	***Release Flow: 275 cfs***		
1	9.5	1.9	0.44
2	14.5	2.4	4.28
3	19.5	2.25	3.94
4	24.5	1.65	3.65
5	29.5	0.9	3.42
6	34.5	1.05	2.71
7	39.5	1.55	1.72
8	44.5	1.6	3.01
9	49.5	1.6	2.6
10	54.5	1.75	1.6
11	59.5	1	0.04

Reported velocities are Mean Column Velocities

Russian River Transect 12 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	9.5	0.2	0
2	12.5	0.8	0.45
3	15.5	1.2	0.51
4	18.5	1.15	0.52
5	21.5	1.1	1.19
6	24.5	1.05	0.96
7	27.5	0.95	1.26
8	30.5	0.75	1.31
9	33.5	0.55	0.7
10	36.5	0.7	0.95
11	39.5	0.85	1.16
12	42.5	0.8	1.33
13	45.5	1.05	1.8
14	48.5	1	1.87
15	51.5	1	2.13
16	54.5	1	2.25
17	57.5	0.9	2.46
18	60.5	0.95	1.64
19	63.5	0.9	0.64
20	66.5	0.6	1.22
21	69.5	0.3	0.42
10/1/01	***Release Flow: 190 cfs***		
1	5.8	0.1	0.01
2	8.6	0.25	0.24
3	11.4	1	1.18
4	14.2	1.45	1.31
5	17	1.55	1.85
6	19.8	1.5	1.82
7	22.6	1.45	1.91
8	25.4	1.3	2.33
9	28.2	1.3	1.88
10	31	1	2.75
11	33.8	0.9	2.1
12	36.6	1.2	2.42
13	39.4	1.2	3.05
14	42.2	1.15	3.33
15	45	1.2	3.09
16	47.8	1.5	2.92
17	51.6	1.3	3.47
18	54.4	1.3	3.05
19	57.2	1.2	3
20	60	1.25	2.67
21	62.8	1.2	2.01
22	65.6	1.1	1.97
23	68.4	0.9	1.29
24	71.2	0.2	0.01

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
10/4/01	***Release Flow: 275 cfs***		
1	5.5	0.2	0.05
2	8.9	0.4	1.18
3	12.3	1.25	1.57
4	15.7	1.5	1.64
5	19.1	1.75	2.1
6	22.5	1.65	1.83
7	25.9	1.4	2.42
8	29.3	1.3	2.86
9	32.7	1.05	2.09
10	36.1	1.2	2.5
11	39.5	1.3	3.09
12	42.9	1.4	3.15
13	46.3	1.55	3.26
14	49.7	1.55	3.34
15	53.1	1.4	3.22
16	56.5	1.35	2.98
17	59.9	1.35	2.46
18	63.3	1.35	2.28
19	66.7	1.1	1.76
20	70.1	0.6	0.07

Reported velocities are Mean Column Velocities

Russian River Transect 13 - measured depths and velocities at observed release flows

Station	Distance (feet)	Depth (feet)	Point Velocity (fps)
9/26/01	***Release Flow: 125 cfs***		
1	6	2.15	0.08
2	12	3.7	0.12
3	18	2.85	0.635
4	24	2.6	0.7
5	30	1.95	0.96
6	36	1.95	1.18
7	42	1.9	1.85
8	48	1.7	0.84
9	54	1.4	0.23
10	60	1	0.4
11	66	0.4	0.13
12	72	0.5	0.02
10/1/01	***Release Flow: 190 cfs***		
1	4	1.7	0.04
2	10	3.7	0.075
3	16	3.5	0.4
4	22	2.8	0.915
5	28	2.45	1.42
6	34	2.25	2.16
7	40	2.36	1.68
8	46	2.2	2.22
9	52	1.9	1.91
10	58	1.6	0.66
11	64	1	0.03
12	70	0.9	0.13
13	76	0.3	0.11
10/4/01	***Release Flow: 275 cfs***		
1	5.4	2.6	0.05
2	13	4.1	0.2
3	20	3	0.645
4	27	2.7	1.43
5	34	2.4	1.78
6	41	2.4	2.18
7	48	2.25	2.82
8	55	1.9	1.87
9	62	1.25	0.65
10	69	0.8	0.09
11	74	0.7	0.16

Reported velocities are Mean Column Velocities

SUMMARY OF HYDRAULIC MEASUREMENTS AT EVALUATION FLOWS

Stream Name: **Dry Creek**

13-Sep

Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	45.71	96.39	58.20	1.66	0.47
T2	39.79	23.10	31.50	0.73	1.72
T2B	39.10	24.08	33.60	0.72	1.62
T3	40.62	34.60	40.00	0.87	1.17
T4	42.52	19.38	30.60	0.63	2.19
T5	41.13	72.80	36.00	2.02	0.56
T6	40.06	32.18	30.75	1.05	1.25
T7	40.52	43.55	35.20	1.24	0.93
T8	41.79	34.95	36.00	0.97	1.20
T9	47.22	18.30	30.00	0.61	2.58

19-Sep

Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	79.77	108.50	63.00	1.72	0.74
T2	93.40	36.85	34.00	1.08	2.53
T2B	84.55	36.70	42.00	0.87	2.30
T3	87.51	47.60	40.00	1.19	1.84
T4	95.03	35.55	36.00	0.99	2.67
T5	78.14	89.28	39.00	2.29	0.88
T6	81.90	42.66	31.30	1.36	1.92
T7	77.42	56.24	36.80	1.53	1.38
T8	74.56	48.15	39.00	1.23	1.55
T9	74.40	28.17	39.60	0.71	2.64

20-Sep

Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	120.21	122.15	56.00	2.18	0.98
T2	125.41	45.75	36.00	1.27	2.74
T2B	128.54	46.00	40.00	1.15	2.79
T3	132.70	56.10	40.00	1.40	2.37
T4	142.78	46.65	42.00	1.11	3.06
T5	110.74	94.00	36.00	2.61	1.18
T6	120.09	48.48	30.40	1.59	2.48
T7	124.62	70.40	38.40	1.83	1.77
T8	126.80	66.45	40.50	1.64	1.91
T9	114.32	39.45	36.00	1.10	2.90

21-Sep

Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	135.08	133.80	57.00	2.35	1.01
T2	149.21	52.60	36.00	1.46	2.84
T2B	158.48	55.10	43.00	1.28	2.88
T3	162.59	64.90	43.00	1.51	2.51
T4	165.21	54.60	40.00	1.37	3.03
T5	139.17	107.80	40.00	2.70	1.29
T6	153.91	59.20	42.00	1.41	2.60
T7	150.30	74.00	38.00	1.95	2.03
T8	146.80	73.00	40.00	1.83	2.01
T9	154.03	49.41	36.00	1.37	3.12

Stream Name: **Russian River**

26-Sep					
Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	109.96	46.50	32.50	1.43	2.36
T2	104.24	91.70	40.00	2.29	1.14
T3	114.84	54.60	76.00	0.72	2.10
T4A&T4B	95.08	50.68	97.00	1.05	3.72
T4C	89.80	139.35	78.00	2.85	1.61
T5	100.73	57.30	66.00	0.87	1.76
T6	98.52	97.95	64.50	1.52	1.01
T7	97.31	62.50	52.50	1.19	1.56
T8	103.09	30.75	30.00	1.03	3.35
T9	4.71	3.05	9.00	0.34	1.55
T10	89.53	43.40	31.50	1.38	2.06
T11	95.28	40.00	45.00	0.89	2.38
comminsky flov	96.02	44.63	28.50	1.57	2.15
T12	63.45	52.80	60.00	0.88	1.20
T13	79.00	117.00	66.00	1.77	0.68

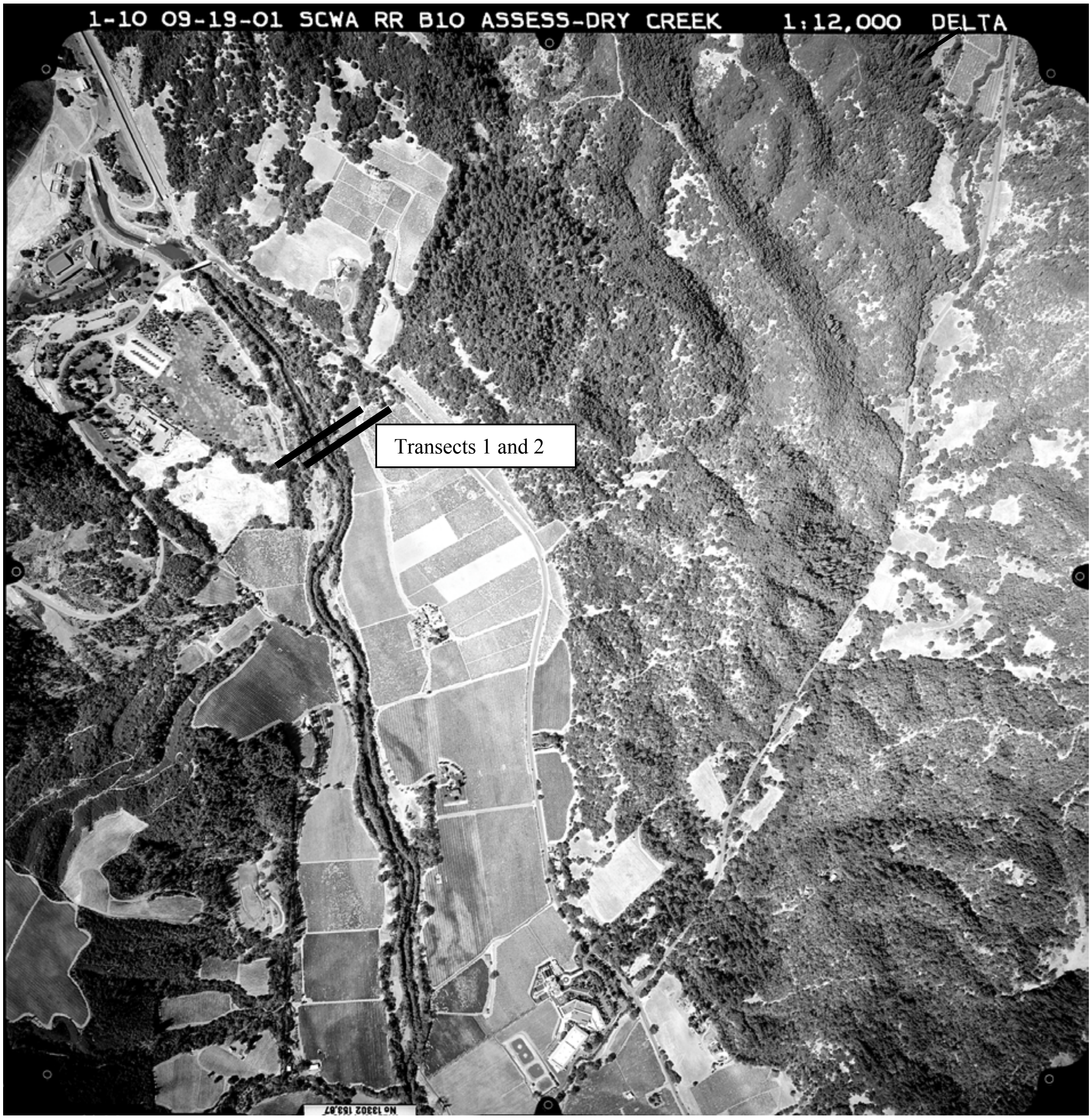
1-Oct					
Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	183.69	58.14	35.00	1.66	3.16
T2	183.82	103.60	40.00	2.59	1.77
T3	202.92	82.60	80.00	1.03	2.46
T4A&B	197.62	70.35	94.00	1.50	5.63
T4C	172.34	150.50	84.60	2.90	2.09
T5	185.79	80.80	72.00	1.12	2.30
T6	168.72	126.71	73.20	1.73	1.33
T7	173.97	97.75	60.00	1.63	1.78
T8	193.30	53.10	55.00	0.97	3.64
T9	10.63	4.90	9.00	0.54	2.17
T10	141.05	63.35	35.00	1.81	2.23
T11	140.70	60.00	50.00	1.20	2.34
comminsky flov	166.06	62.93	30.00	2.10	2.64
T12	167.55	75.32	65.40	1.15	2.22
T13	156.21	146.66	72.00	2.04	1.07

4-Oct					
Transect	Total Discharge (cfs)	Total Area (sq ft)	Total Width (ft)	Mean Depth (ft)	Mean Velocity (fps)
T1	279.24	73.40	36.00	2.04	3.80
T2	279.73	116.60	44.00	2.65	2.40
T3	280.91	102.00	80.00	1.28	2.75
T4A&T4B	271.80	81.00	94.00	1.74	6.76
T4C	231.57	166.90	90.00	3.13	2.82
T5	243.34	89.20	72.00	1.24	2.73
T6	231.83	155.40	73.50	2.11	1.49
T7	215.06	116.40	63.00	1.85	1.85
T8	236.39	72.40	60.00	1.21	3.27
T9	15.74	5.60	10.00	0.56	2.81
T10	183.72	70.70	37.50	1.89	2.60
T11	232.01	78.75	50.00	1.58	2.95
comminsky flov	203.26	71.48	30.00	2.38	2.84
T12	196.24	83.13	64.60	1.29	2.36
T13	187.90	149.10	68.60	2.17	1.26

ATTACHMENT F

AERIAL PHOTOS SHOWING
FLOW ASSESSMENT TRANSECT LOCATIONS

Attachment F
Flow Assessment Transect Locations – Dry Creek



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Flow Assessment Transect Locations – Dry Creek

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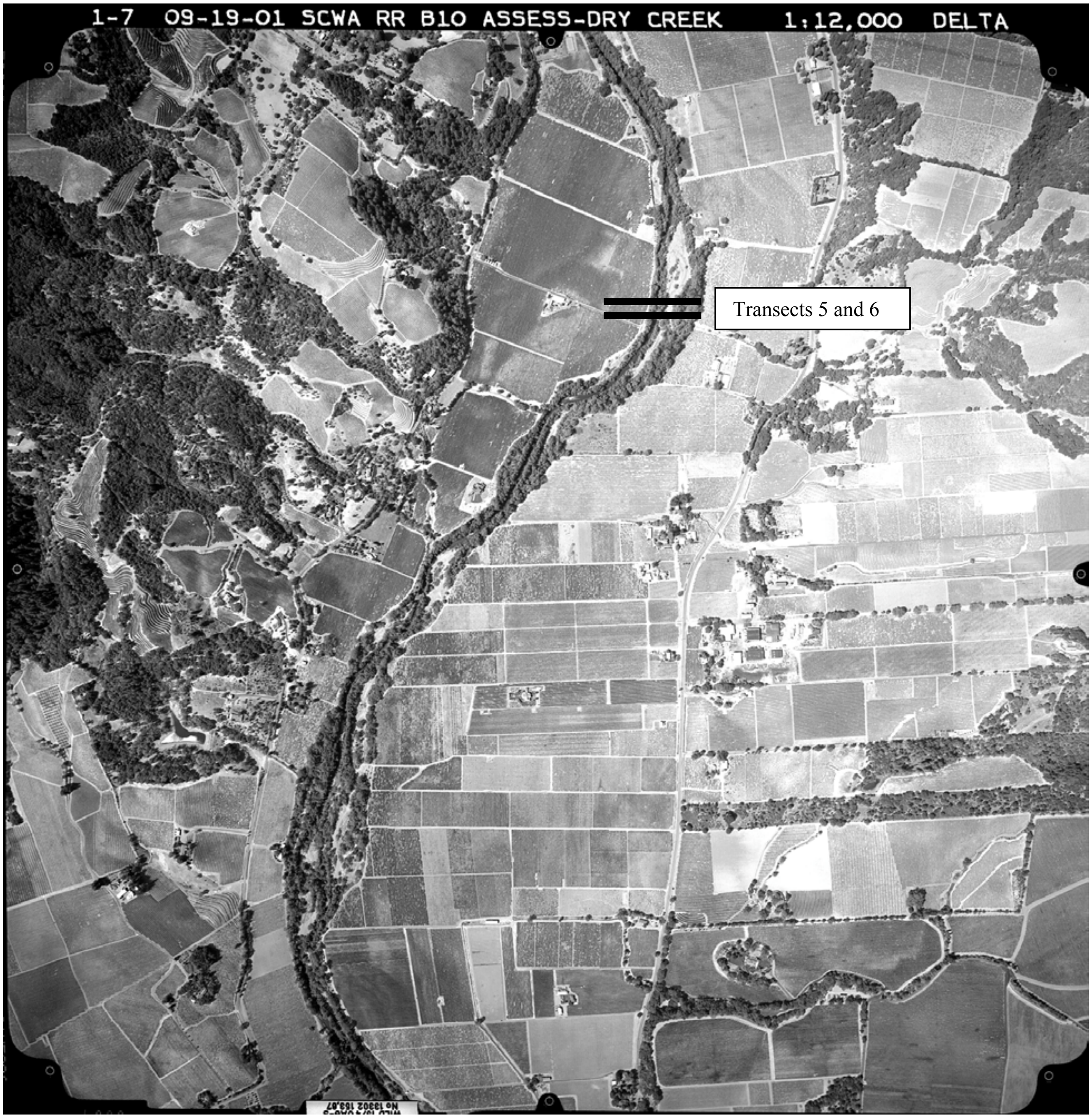
Flow Assessment Transect Locations – Dry Creek



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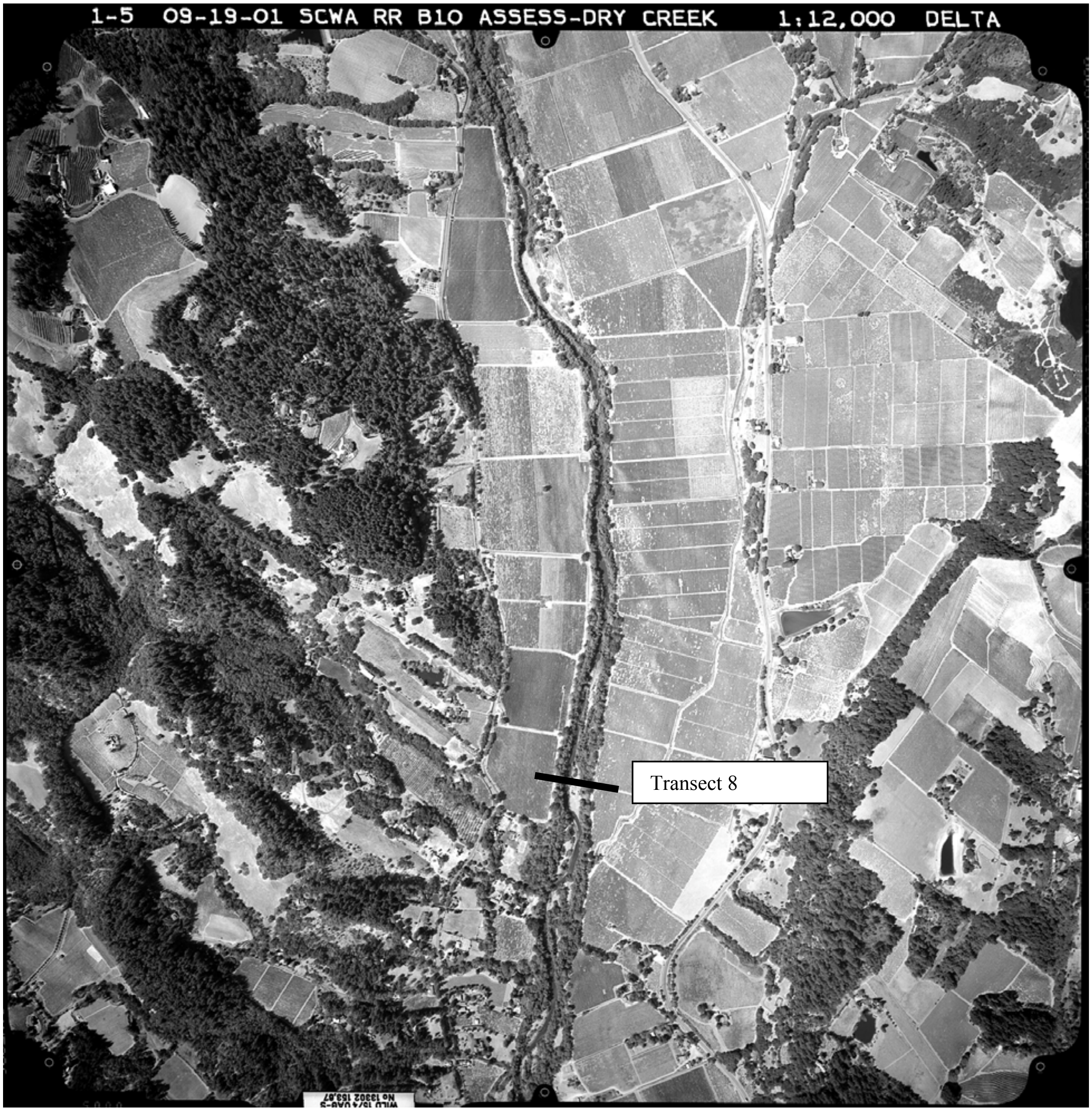
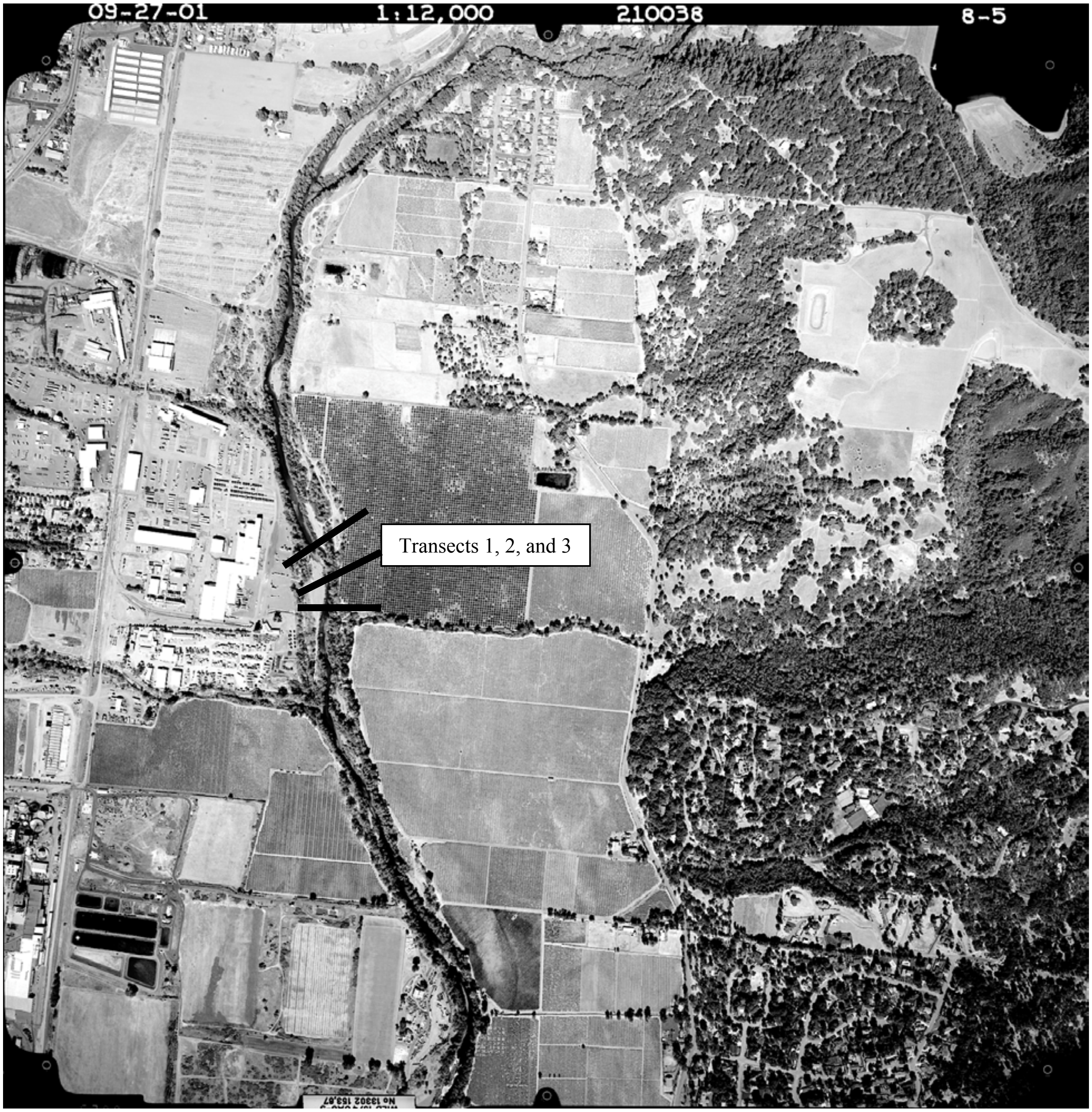
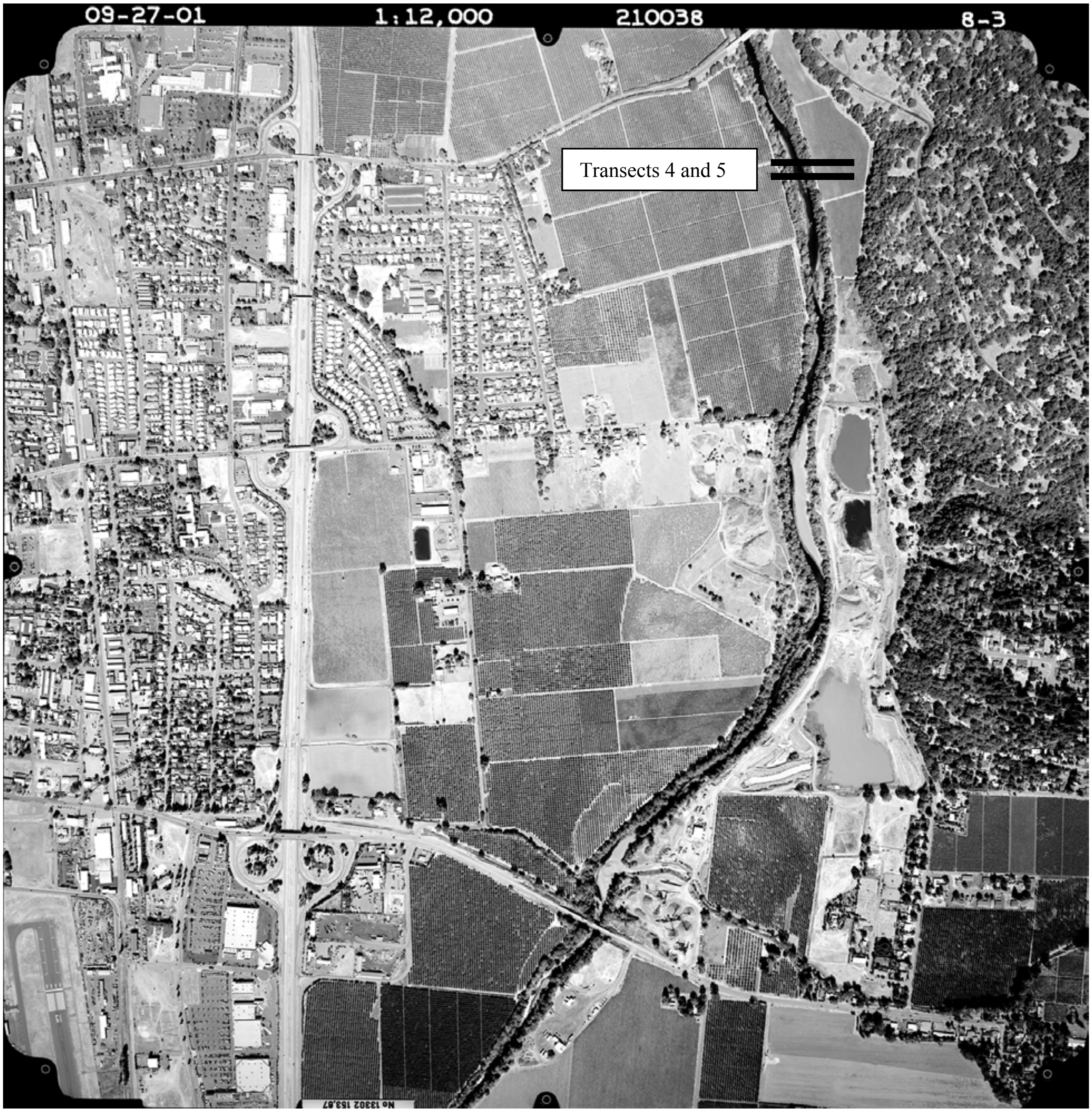


Attachment F
Flow Assessment Transect Locations – Dry Creek

Attachment F
Flow Assessment Transect Locations – Russian River



Attachment F
Flow Assessment Transect Locations – Russian River



Attachment F
Flow Assessment Transect Locations – Russian River

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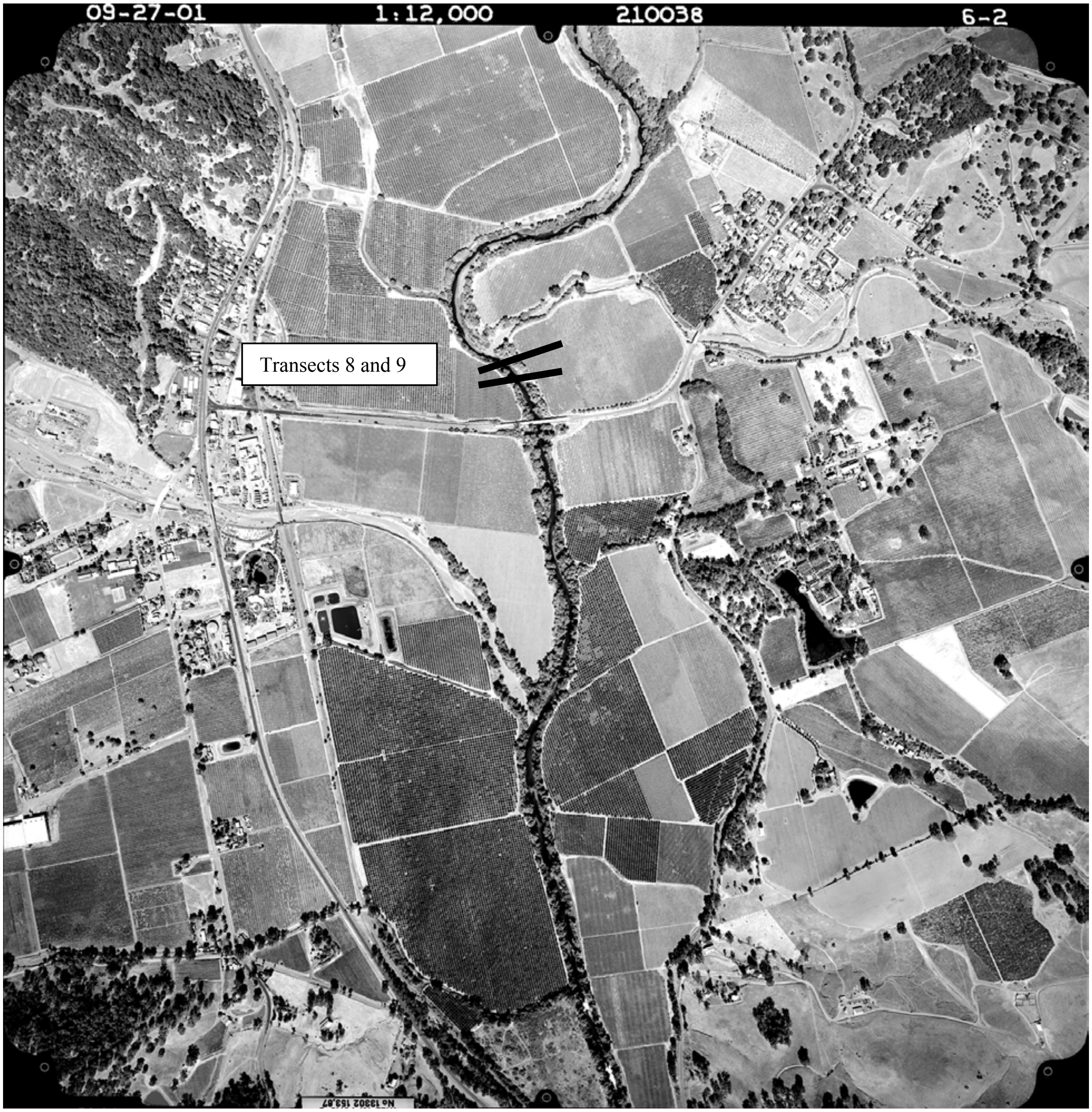
Flow Assessment Transect Locations – Russian River



Attachment F
Flow Assessment Transect Locations – Russian River

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